AD-A250 098

2003022502[4]

2

MIPR NO: 90MM0526

TITLE: MICROSAINT MODELS OF THE CLOSE-IN WEAPON SYSTEM (CIWS): SENSITIVITY STUDIES AND CONFORMAL MAPPING OF PERFORMANCE DATA (CISWENS)

SUBTITLE: Exploring the Utility MicroSAINT Models: CIWS Loading Operation Models Under Normal and MOPP IV Conditions

PRINCIPAL INVESTIGATOR: Forrest D. Holcombe, LCDR, MSC, USN

CONTRACTING ORGANIZATION: Naval Medical Research & Development Command, Naval Medical Command
National Capital Region
Bethesda, MD 20814

P.I. ADDRESS: Naval Biodynamics Laboratory
P.O. Box 29407
New Orleans, LA 70189-0407

REPORT DATE: May 31, 1991

TYPE OF REPORT: Final Report

PREPARED FOR: U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
Fort Detrick, Frederick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for public release; distribution unlimited

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	31 May 1991	Final Report (11/1/89 - 5/31/91)

4. TITLE AND SUBTITLE
MicroSAINT Models of the Close-In Weapon System (CIWS): Sensitivity Studies and Conformal Mapping of Performance Data (CISWENS)

5. FUNDING NUMBERS
MIPR No:
90MM0526

0603002A
3M263003D995.BG.048
WUDA331007

6. AUTHOR(S)
Forrest D. Holcombe; Louis Tijerina; Delia Treaster

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Medical Research & Development Command
Naval Medical Command
National Capital Region
Bethesda, MD 20814

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Development Command
Fort Detrick
Frederick, Maryland 21702-5012

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Subtitle: Exploring the Utility MicroSAINT Models: Sensitivity Studies and Conformal Mapping of Performance Data (CISWENS)

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

Recent work on technology to describe and predict soldier performance in conventional and chemical warfare scenarios has led to the development of a sequential network simulation software system called Micro SAINT. The objective of this study was the application of Micro SAINT simulation models of the Close-In-Weapons Systems (CIWS) loading operation to describe and predict performance on a multi-man operation in both conventional and CBR-D conditions.

This study made use of Micro SAINT simulation and an operations research scheduling heuristic to identify procedural enhancements to the loading operation and assess the impact of different manning levels (2-man through 5-man crews) on completion times. Data from an existing Army database of tasks performed in shirtsleeve and in MOPP IV gear was fed into Micro SAINT models of the CIWS weapon loading operation to estimate the effects of MOPP IV on this topside operation. A taxonomic approach based on human abilities was attempted in order to assess the comparability of tasks in the Army database to CIWS loading tasks and subtasks. The taxonomic approach offers great promise in facilitating human performance modeling and database development in the future. Issues in applying the taxonomic (human abilities) approach are discussed.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Close-In-Weapons Systems (CIWS), Micro SAINT, Human Abilities, RA 5	141
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

FOREWORD

Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the U.S. Army.

JBH Where copyrighted material is quoted, permission has been obtained to use such material.

JBH Where material from documents designated for limited distribution is quoted, permission has been obtained to use the material.

JBH Citations of commercial organizations and trade names in this report do not constitute an official Department of the Army endorsement or approval of the products or services of these organizations.

N/A In conducting research using animals, the investigator(s) adhered to the "Guide for the Care and Use of Laboratory Animals," prepared by the Committee on Care and Use of Laboratory Animals or the Institute of Laboratory Animal Resources, National Research Council (NIH Publication No. 86-23, Revised 1985).

N/A For the protection of human subjects, the investigator(s) have adhered to policies of applicable Federal Law 45CFR46.

N/A In conducting research utilizing recombinant DNA technology, the investigators(s) adhered to current guidelines promulgated by the National Institutes of Health.

Principal Investigator's Signature	28 JUNE 91 Date

EXPLORING THE UTILITY OF Micro SAINT MODELS: PREDICTIVE SIMULATION WITH THE CIWS LOADING OPERATION MODELS UNDER NORMAL AND MOPP IV CONDITIONS

to

U.S. NAVAL BIODYNAMICS LABORATORY

May 31, 1991

by

Louis Tijerina
Delia Treaster

BATTELLE
505 King Avenue
Columbus, OH 43201

ACKNOWLEDGEMENTS

The authors wish to thank Dr. Edwin Fleishman of George Mason University, and Dr. Jerrold M. Levine of Integrated Systems Research Corp., for providing human abilities assessment support materials. We also acknowledge the assistance of Ms. Tammy Ramirez, Battelle, in accessing and understanding the contents of the Ballistics Research Laboratory (BRL/P^{2}NBC^2) database. Finally, the authors acknowledge the contributions of Dr. Marc Posner and Mr. Kyong Sik Park, Ohio State University Industrial and Systems Engineering Dept., for development of the GREEDY scheduling heuristic.

Executive Summary

A better understanding of human performance in conditions of Chemical, Biological, and Radiological Defense (CBR-D) plays an important part in the ability of U.S. forces to not only survive but prevail in the event of enemy chemical attack. Recent work on technology to describe and predict soldier performance in conventional and chemical warfare scenarios has led to the development of a sequential network simulation software system called Micro SAINT. The objective of this study was the application of Micro SAINT simulation models of the Close-In Weapon System (CIWS) loading operation to describe and predict performance on a multi-man operation in both conventional and CBR-D conditions.

The first task of this study made use of Micro SAINT simulation and an operations research scheduling heuristic to identify procedural enhancements to the loading operation and assess the impact of different manning levels (2-man through 5-man loading crews) on completion times. The results can be used by the Fleet in two ways. First, the enhanced procedures described in this report can be integrated into the CIWS training curriculum and provide a standardized approach to CIWS weapon loading as part of the SEAOPS surface fleet standardization program. Second, the manning impact assessments can provide commanders with some indication of the effects of crew downsizing or augmentation on expected completion times to load or reload the CIWS.

The second task of this study was to take data from an existing Army database of tasks performed in shirtsleeve and in MOPP IV gear and feed Micro SAINT models of the CIWS weapon loading operation to estimate the effects of MOPP IV on this topside operation. A taxonomic approach based on human abilities was attempted in order to assess the comparability of tasks in the Army database to CIWS loading tasks and subtasks. Task Time Multipliers (TTMs), a ratio of MOPP IV completion time over shirtsleeve completion time, would be used to modify the Micro SAINT simulations in the laboratory without the need to collect additional data. For reasons described in this report, this modeling effort proved infeasible. However, the taxonomic approach offers great promise in facilitating human performance modeling and database development in the future. Issues in applying the taxonomic (human abilities) approach are discussed.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION 1.0

INTRODUCTION

1.1 Background

The Department of Defense in general and the U.S. Navy in particular must consider the potential threat of CB attack against our forces and plan for an organized defense against such insidious threats. In this regard, research has shown that human performance in conditions of Chemical, Biological, and Radiological Warfare Defense (CBR-D) is often degraded to the point that the tactical situation may be severely compromised. A better understanding of human performance in conditions of CBR Defense therefore plays an important part in the ability of our forces to not only survive but prevail in this environment. Recent work on technology with which to predict soldier performance in conventional and chemical warfare scenarios has led to the development of a sequential network simulation software system called Micro SAINT. The application of Micro SAINT simulation to describe and predict military personnel performance in both conventional and CBR conditions was the object of this study.

The Close-In Weapon System (CIWS) is the focus of this modeling effort. It is a last ditch defense against antiship missiles or aircraft which have penetrated other fleet defenses. It combines a single mount fire-controlled radar and a six barrel Gatling gun firing depleted uranium projectiles at a rate of 3,000 rounds per minute. The Navy has installed or will install 869 CIWS aboard 44 classes of ships over the next 15 - 20 years (Weapons/Navy, 1990), making this system a significant part of the Navy inventory. The CIWS automatically carries out search, detection, threat evaluation, tracking and firing. However, the loading of the gun is a manual task conducted topside with crews of from two to six members uploading rounds into an ammunition canister. Due to its manual nature, the loading operation is potentially susceptible to degradation from shipboard motion, MOPP IV gear encumbrance, and other environmental forces.

Under contract to the Naval Biodynamics Laboratory (NAVBIODYNLAB), Tijerina and Treaster (1987) and Treaster and Tijerina (1988) developed Micro SAINT computer simulations of the Close-In Weapon System (CIWS) loading operation with a three-man crew. While validation and sensitivity analysis of the models have been pursued, no attempts to use the models to solve problems have yet been made. Such applications work is clearly needed in order to explore the utility of Micro SAINT models. Useful results derived from Micro SAINT models should promote further use of Micro SAINT simulation technology to model human performance in other shipboard applications in the future. In addition, this study will allow for an investigation on how databases of human performance in CBR-D conditions may be used in conjunction with Micro SAINT simulation technology to predict human performance in the CBR-D environment.

1.2 Objectives

In order to explore the utility of Micro SAINT models of the CIWS loading operation, the objectives of this effort were to:

1) seek out procedural enhancements to the loading operation,

2) assess the impact of different manning levels (2-man through 5-man teams) on completion times, and

3) use data from an existing human performance database to predict changes in completion times when the crew is in MOPP IV gear vs. completion times when the crew is in standard-issue (shirtsleeve) clothing.

If successful, the above applications would offer the surface fleet three valuable products. First, procedural enhancements which are discovered could be fed into the CIWS training program and offer the surface fleet a standardized approach to loading the CIWS, as could assessments of the impact of different loading crew sizes. Second, this type of data could offer ship COs with information on the tradeoffs between additional crew allocations and loading operation times. Third, the Micro SAINT models could, if fed with data from an existing database on human performance in MOPP IV, offer a useful predictive system for assessing the impacts of the performance shaping factor of MOPP gear to support commanders' decision making in conditions of Chemical, Biological, and Radiological Defense. These models might also provide more realistic CBR-D overlays to wargaming and other combat simulations. Any difficulties in meeting the objectives for this proposed project should shed light on issues in human performance modeling and directions towards their resolution.

1.3 Methodology

This effort consisted of two tasks. The first was directed toward investigating procedural and manning enhancements in the CIWS loading operation under normal (shirtsleeve) conditions. The second task was oriented toward developing Micro SAINT models which predict the impact of MOPP IV individual protective equipment by attempting to integrate data from an existing database on human performance under such conditions. Approaches taken to these tasks are introduced below.

<u>Task 1. Manipulate Micro SAINT Models to Evaluate Procedural and Manning Impacts on Completion Time</u>. In order to complete this task, Battelle conducted a human factors analysis of the CIWS loading operation using primarily CIWS documentation and video tapes of crews performing the loading operation. Based on this analysis, Battelle developed a scheduling heuristic with which to reallocate activities across different crew sizes over a range of two to five members. Modified models were then run many times and completion times statistics were examined to determine the degree of improvement in completion times obtained. Modeling assumptions and lessons learned in this effort were discussed. Prior to the start of this project, additional data collection for validation of models derived from Task 1 was determined to be beyond its scope.

<u>Task 2. Evaluate the Impact of MOPP IV on CIWS Loading Times</u>. The objective of this task was to attempt to make use of an existing database of 300 Army maintenance tasks done with and without MOPP IV gear compiled by the U.S. Army Ballistics Research Laboratory (BRL). In order to complete this task, the following activities were undertaken. First, CIWS loading operation tasks and activity elements were analyzed for the human abilities involved. This characterization was intended to provide a common vocabulary for both CIWS tasks and tasks in the BRL database. Second, the BRL database was examined for tasks similar to those which comprise the CIWS loading operation. The hope was that the database would provide the completion time deltas or Task Time Multipliers (TTMs) needed to configure the existing baseline CIWS models for the MOPP IV condition. A caveat voiced in the proposal to this effort was that it might not be possible to construct MOPP IV models due to lack of appropriate data from the BRL database; this turned out to be the case. As indicated in Task 1, collection of additional data to fill in such data gaps was <u>not</u> considered within the scope of the present study. The Micro SAINT models in the MOPP IV therefore were not constructed. Instead, the impediments to and opportunities for modeling have been documented to serve as the report for Task 2.

SECTION 2.0

TASK 1. Micro SAINT Evaluation of Procedural and Manning Impacts

2.1 Background

The objective of this task was to manipulate the existing baseline models of the CIWS loading operation, in the laboratory and without additional data collection, to determine enhanced loading procedures for crew sizes ranging from 2 to 5 crew members. Videotaped data on CIWS weapon loading operations in the fleet indicated there was no standard loading crew size. Furthermore, even for a given crew size of 3 men, the authors observed considerable procedural variation across two different crews. This suggested an opportunity to provide the Fleet with an "optimal" procedure for a given crew size and insights into the effects of different crew sizes. The methods used and results obtained are described below.

2.2 Method

Development of a Baseline CIWS Loading Operation Network Diagram

The first step in accomplishing the objective of Task 1 was to create a baseline network diagram of the CIWS loading operation which was free of manning constraints and the crew idiosyncracies captured in earlier modeling efforts. (See Table 2.2.1 for a description of the activity elements which comprise the CIWS loading operation). Tijerina and Treaster (1987) and Treaster and Tijerina (1988) reported models which explicitly indicated the crew position(s) involved in an activity element. These models also captured all variations in procedure which were exhibited by each of the two loading crews. By contrast, the starting point for the present effort was a baseline network diagram based solely on stable precedence relations among activity elements which comprise the loading operation, without regard for who might perform them. To develop an understanding of these precedence relations, the authors reviewed the videotapes of the two crews loading the CIWS upon which the earlier Micro SAINT models were based. Additional information regarding the sequence of the tasks was gleaned from the CIWS technical manual. Also, the existing Micro SAINT models were reviewed. Lastly, the researchers' judgement, based on the sum of their experiences in modeling the operation, was used to make decisions on the final representation of the baseline CIWS network. Table 2.2.2 shows the precedence relationships for all of the activity elements along with completion time data and crew requirements. From this table, the baseline CIWS network diagram presented in Figure 2.2.1 was developed.

Determination of Activity Element Completion Times

In addition to the baseline CIWS network diagram, completion time statistics (means, variances) were needed for each of the loading operation's activity elements. At this point it is important to point out that the sequence of tasks depicted in Figure 2.2.1 is not exactly like one observed in the previous CIWS modeling efforts. However, since the purpose of the present task was to explore how Micro .

Table 2.2.1 Description of CIWS Loading Operation Activity Elements

Task #	Description of Element	Start/End States
Task 1: Set Up		
1	Unlock door	START: Operator touches (first) lock END: Operator releases (last) lock
2	Undo dogs	START: Operator touches bar or hasp END: Operator releases hand from bar or hasp
3	Open door	START: Operator touches door END: (All doors open) Operator releases hand from last door prop
4	Move box 1	START: Operator touches box in locker END: (Box set on deck) Operator releases box and begins to rise
5	Move box 2	
6	Move box 3	
7	Move box 4	
8	Move box 5	
9	Move loader	START: Operator touches loader in locker END: (Loader placed at mounting area in CIWS) Operator releases loader
Task 2: Install Loader		
10	Remove shield pins	START: Operator lays hand(s) on fastener/first fastener pulled out END: (All fasteners removed) Operator lays hand(s) on shield to lift off
11	Stow shield	START: Operator lays hand(s) on shield to lift off END: (Operator has set shield aside) Operator releases hand(s) from set-aside shield; arm movement indicates shield release
12	Time drum	START: Operator places hand on timing button END: Operator removes hand from timing button
13	Open rounds latch	START: Operator touches latch assembly/pins END: Operator releases pin with latch in downward position
14	Position loader	START: Operator releases pin with latch in downward position or: Operator begins to move loader to mount END: (Loader in place) Operator places hand on any fastener
15	Secure loader	START: Operator places hand on a fastener END: Operator releases hand from last fastener
16	Align L's & R's	START: Operator bends down and looks into peep-hole to check gear status END: Operator begins to rise
Task 3: Feed Belt/Load Rounds		
17	Release tray	START: Operator lays hand on side tray clip END: (Loader tray unclipped) Operator releases side tray clip
18	Lift & fasten tray	START: Operator begins to lift up tray END: (Tray in up position and fastened in place) Operator releases tray
19	Hand off belt	START: Belt moves into view (Deck person hands to Crew Member #2) END: Belt end comes into contact with feeder
20	Start belt end	START: Belt end comes into contact with feeder END: Operator places hand on stowed tray or tray hook
21	Lower loader tray	START: Operator places hand on stowed tray or tray hook END: (Tray is in down position) Operator releases lowered tray
22	Lock tray	START: Operator places hand on side latch END: (Tray is latched) Operator releases tray latch

Table 2.2.1 Description of CIWS Loading Operation Activity Elements (cont.)

23	Finish belt positioning	START: (Tray is in down position) Operator places hand on wrench/wrench is turned END: Operator releases set-aside wrench
24 25 26 27	Clip belt ends (1&2) Clip belt ends (2&3) Clip belt ends (3&4) Clip belt ends (4&5)	START: Operator brings ends of belts together END: Operator moves hands away from connected belts
28	Activate hydraulics	START: Operator moves toward hydraulic switch (reaches) END: Operator places hand on manual feed-rate control lever
29 30 31 32 33	Upload rounds (1) Upload rounds (2) Upload rounds (3) Upload rounds (4) Upload rounds (5)	START: Operator places hand on manual feed-rate control END: End of belt exits (falls out of) loader
Task 4: Stow Loader		
34	Deactivate hydraulics	START: Belt falls free of loader tray END: (Hydraulics deactivated) Operator removes hand from hydraulics switch
35	Remove fasteners	START: Operator removes hand from hydraulics switch END: (All fasteners loosened) Operator begins to lift loader
36	Lift loader	START: Operator begins to lift loader END: (Loader removed and set aside) Operator releases grip on loader
37	Secure rounds latch	START: Operator lays hand(s) on latch assembly END: Operator releases latch assembly/pins
38	Grasp shield	START: Operator releases latch assembly/pins END: Operator lays hand(s) on shield
39	Position shield	START: Operator begins to lift shield into position END: (Shield situated in place) Operator reaches for first fastener
40	Fasten shield	START: Operator reaches for first fastener END: (All fasteners secure) Operator removes hand(s) from fasteners

Table 2.2.2 CIWS Loading Operation Precedence Relations and Completion Times

CIWS LOADING OPERATION

Activity Element	Immediate Functional Predecessor	Time to Complete MEAN	Time to Complete VAR	# Crew Required
TASK 1: SET UP				
1 Unlock locker	—	16.2*	3.06	1
2 Undo dogs	1 unlock locker	28.5*	456.6[illegible]	1
3 Open locker door	2 undo dogs	6.6*	5.24	2
4 Move box 1	3 open locker door	14.2[2]	1.7	1
5 Move box 2	3 open locker door	14.2[2]	1.7	1
6 Move box 3	3 open locker door	14.2[2]	1.7	1
7 Move box 4	3 open locker door	14.2[2]	1.7	1
8 Move box 5	3 open locker door	14.2*	1.7	1
9 Move loader	3 open locker door	7.1[2]	.85	1
TASK 2: INSTALL LOADER				
10 Remove shield pins	—	7.5[2]	10.2	1
11 Stow shield	10 remove shield pins	3.0*	2.2	1
12 Time drum	—	25.7[2]	154.9	2
13 Secure rounds latch	11 stow shield	7.32*	8.44	1
Alternative 1:				
14 Position loader	9 move loader 13 secure rounds latch 12 time drum	8.9[1]	3.66	1
15 Secure loader	14 position loader	17.6[1]	35.03	2
Alternative 2:				
14 Position loader	9 move loader 12 time drum 13 secure rounds latch	11.5*	11.53	2
15 Secure loader	14 position loader	23.5[2]	70.3	2
16 Align L's and R's	15 secure loader	20.5[2]	42.3	2
TASK 3 FEED BELT LOAD ROUNDS				
17 Release tray	15 secure loader	1.7[1]	.24	1
18 Lift & fasten tray	17 release tray	5.5[1]	7.51	1
19 Hand off belt	18 lift and fasten tray	3.4[1]	.36	2
20 Start belt end	19 hand off belt	34.5[1]	97.31	1
21 Lower loader tray	20 start belt end	2.5[1]	1.05	1
22 Lock tray in place	21 lower loader tray	6.7[1]	19.47	1
23 Finish belt positioning	21 lower loader tray	16.2[1]	25.03	1

Table 2.2.2 CIWS Loading Operation Precedence Relations and Completion Times (cont.)

Activity Element	Immediate Functional Predecessor		Time to Complete ME	Time to Complete VAR	# Crew Required
24 Clip belt ends (1&2)	23	finish belt position	11.9[1]	171.53	1
	4	move box 1			
	5	move box 2			
25 Clip belt ends (2&3)	5	move box 2	11.9[1]	171.53	1
	6	move box 3			
26 Clip belt ends (3&4)	6	move box 3	11.9[1]	171.53	1
	7	move box 4			
27 Clip belt ends (4&5)	7	move box 4	11.9[1]	171.53	1
	8	move box 5			
28 Activate hydraulics	23	finish belt position	4.5[2]	2.92	1
29 Upload rounds (1)	28	activate hydraulics	9.9[2]	2.74	2
30 Upload rounds (2)	24	clip belt ends (1&2)	9.9[2]	2.74	2
	29	upload rounds (1)			
31 Upload rounds (3)	25	clip belt ends (2&3)	9.9[2]	2.74	2
	30	upload rounds (2)			
32 Upload rounds (4)	26	clip belt ends (3&4)	9.9[2]	2.74	2
	31	upload rounds (3)			
33 Upload rounds (5)	27	clip belt ends (4&5)	9.9[2]	2.74	2
	32	upload rounds (4)			
TASK 4 STOW LOADER					
34 Deactivate hydraulics	33	upload rounds (5)	2.2[2]	.8	1
35 Remove loader	34	deactivate hydraulics	11.5[2]	8.27	1
36 Lift loader	35	remove loader	5.34*	4.3	1
37 Secure rounds latch	36	lift loader	6.33*	6.43	1
38 Grasp shield	37	secure rounds latch	2.71*	5.71	1
39 Position shield	38	grasp shield	5.73*	4.77	1
Alternative 1:					
40 Fasten shield	39	position shield	5.9[1]	6.0	2
Alternative 2:					
40 Fasten shield	39	position shield	12.0[2]	[illegible]	1

Notes:
1 = time values derived from Crew #1
2 = time values derived from Crew #2
* = time values averaged between Crew #1 and #2

The MEAN was computed as:

$$MEAN = \frac{n_1\bar{Y}_1 + n_2\bar{Y}_2}{n_1 + n_2 - 2}$$

The variance VAR was computed as a pooled estimate:

$$VAR = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

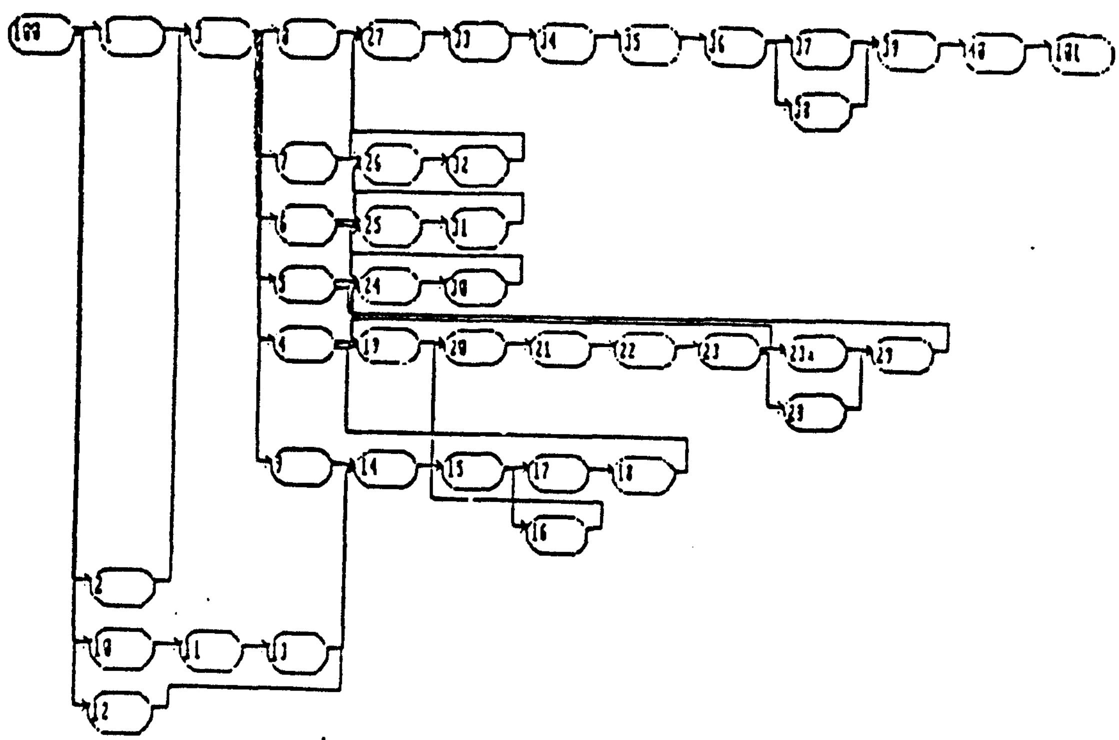


Figure 2.2.1 Baseline CIWS Network Diagram, Micro SAINT output. (Note: See Table 2.2.1 for activity element definitions. Activity Element 100 is a dummy "start" task; Activity Element 101 is a dummy "finish" task).

SAINT models might be used to answer "what if..." questions without collecting new data, necessary completion time values for each activity element in the baseline network had to be extracted from the existing model data.

The procedure by which this was done was as follows. Mean completion times for the baseline network were based on the field data previously collected and analyzed in Tijerina and Treaster (1987) and Treaster and Tijerina (1988). In cases where the two previously modeled crews performed the same activity element in the same manner, an average in completion times between the two crews (pooled estimate) was judged by the authors to be most representative. In other cases, the loading method demonstrated by one crew was determined to represent the superior approach (in terms of completion time and effort), so the time values for that crew on those activity elements were used. Variances for completion times were likewise calculated from the empirical data. In some instances, the variances from the two crews were combined to obtain a pooled estimate. In instances where only one crew's data was used, the variance associated with that crew was taken. Finally, the number of crew members needed to complete the activity element was determined by review of the CIWS videotapes, documentation, and the authors' estimation as human factors engineers familiar with the weapon loading operation. Table 2.2.2 shows the values for mean completion time, completion time variance, and required number of crew members which were used for the model. Based on earlier analysis reported in Treaster and Tijerina (1988), the Gamma distribution was assumed for all completion time distributions.

Additional assumptions were made in the process of generating the precedence relationships. The first of these assumptions concerned the orientation of the CIWS in relation to the mounting base. For purposes of modeling, it was assumed that the barrel of the gun was pointed starboard. This allowed a crew member to activate the hydraulics switch by reaching down from the mounting platform, rather than walking around to the far side of the CIWS. However, this implied that one crew member was needed on the far side of the CIWS to assist with timing the drum and aligning the gears with the spanner wrench. Communications were required between crew members to coordinate the timing and aligning portions of the loading process. It was assumed that five boxes of ammunition (dummy rounds) were removed from the locker and uploaded into the ammunition canister. The time required to transport each box and remove the belt from the box was assumed to be the same for all boxes. Completion times for each activity element were assumed to always follow the distributional parameters given in Table 2.2.1 with the Gamma distribution used as a default. Individual differences in performance (both in terms of completion times and error rates) between crew members were not modeled. Furthermore, the baseline network diagram did not explicitly include a 'transit' task for crew members to transit from one area to another. These simplifying assumptions represented what appeared to be the most reasonable approach to the loading operation in terms of convenience and speed.

GREEDY: A Scheduling Heuristic

Given the baseline network representation of the CIWS loading operation and associated completion time data, what was needed next was a reasoned approach to making the manning and procedural allocations. One way of developing the enhanced loading procedures is to consider it a special problem in scheduling and make use of operations research techniques. The scheduling problem has demonstrated itself to be an extremely difficult one. Combinatorial explosion often makes it

impossible to enumerate all scheduling options except for small problems. Therefore, operations researchers look toward heuristic algorithms which, if they do not find mathematically optimal solutions, find very good or near-optimal solutions. In the present case, "optimal" manning policies and procedures for different crew sizes were developed using CPM and a scheduling heuristic, GREEDY, developed especially for this project. The GREEDY heuristic, described below was coded in FORTRAN and run on a VAX 750:

1 Find the set of jobs, called candidates jobs, for which all predecessors have been completed (candidate jobs are the set of jobs that are available for processing).
2 Sort the candidate jobs in decreasing order of Latest Starting Time (LST). (LST is the latest time that a job can start without delaying the completion of the project).
3 Select the first candidate job and call it c.
4 Find the job with the smallest LST value among all unprocessed jobs (not just the candidate jobs). Call this job s.
  If c $\neq$ s, go to 5.
  Otherwise, if there are enough people available, then process the job. Go to 6.
5 Find the job with the smallest LST value that needs two men. Check if processing c now will delay the processing of this job. If not, then process c.
6 Pick the next job in the candidate list. If there is a candidate job left, and an available person, then go to 4. Otherwise, go to 7.
7 Find the next time that a job is completed. Update time. If there are jobs left to be processed, go to 1. Otherwise, STOP.

The GREEDY heuristic is so called because it makes use of a priority rule which "greedily" grabs available crew members to staff the next task which, if not started, will delay the completion of the entire loading operation.

The GREEDY heuristic was run for each crew size ranging from 2 to 5 crew members. The results of GREEDY were then inspected by the authors for reasonableness. This was necessary in order to factor in rules which were not part of the GREEDY heuristic, such as the inclusion of transit times from one location to another and a rule that assigns the same person to a set of logically related tasks that are accomplished from the same location.

Micro SAINT Models of Alternative CIWS Manning

The GREEDY heuristic, combined by inspection of its results by human factors engineers for reasonableness, resulted in manning allocations for each of the loading crew sizes from 2 to 5 men. These manning allocations were then modeled in Micro SAINT to assess their impact on total time to complete the loading operation. Each model was run 100 times, after which summary statistics (means, variances) were collected.

2.3 Results

Figures 2.3.1 through 2.3.4 depict the timelines generated by GREEDY (suitably modified by the authors to take into consideration location constraints). These timelines provide a clear indication of what each crew member's role. Note that the numbers above the timelines represent the cumulative sum of mean completion times associated with each of the CIWS loading operation activity elements whose numbers are given below the timeline. This result obtains because a Critical Path Method (CPM) analysis was carried out in order to provide GREEDY with Latest Starting Times (see Appendix A for a description of the calculations and logic). CPM and GREEDY both treat completion time as fixed. It is also worth noting that alternative solutions are possible, though the likelihood that one exists which is significantly superior to those presented is considered small.

In preparing GREEDY, Dr. Marc Posner and Mr. Kyong Sik Park of the Ohio State University worked on a structurally simpler network representation for which they developed a decomposition theorem. For the simpler network used to develop GREEDY, optimal results could be determined through enumeration, a fact which allowed for an assessment of the quality of GREEDY scheduling results. Table 2.3.1 presents the results of that evaluation. While not a rigorous test of the heuristic, it appears that GREEDY holds promise in generating optimal (or near-optimal) solutions. The GREEDY results are fairly close to the optimal ones, and in some cases, the two are the same.

Consider next the Micro SAINT simulation results, are given in Table 2.3.2 and graphed in Figure 2.3.5. As can be seen in the figure, the greatest benefit from adding additional crew members to assist in the loading operation is seen in increasing from two to three members. Thereafter, the increase in crew size has relatively little effect on shortening the mean completion time. For comparison, the baseline data are also provided. The baseline data represent the Micro SAINT completion times with <u>no</u> restriction on the number of crew members available to do the operation. It therefore indicates the 'best' that a loading crew could do given as many hands as desired.

The results in Figure 2.3.5 indicate that the 2-man and 4-man crews exhibited the most variability. In the first case, this may be attributed to the fact that any delay in the completion time of an activity element could not be compensated for by available crew because there were only two men, i.e., the loading operation is, in some sense, understaffed. Thus, if everything worked like clockwork, the loading operation was completed quickly. Otherwise a delay in even a few tasks could severely impact the completion time because there were no extra hands to 'take up the slack'. In the 4-man case, the wide variability might be due to the fact that, especially in the early phases of the loading operation, multiple crewmembers needed to coordinate tasks each with its own independent variance. The multiplicity of variances operating at the same time could lead to lengthened completion times when things went awry (i.e., when several of these concurrent tasks had, by chance, long completion times). On the other hand, if all went well, the four-man crew was able to complete the task in minimum time (relative to the baseline). It is interesting to note that the CIWS school at Treasure Island trains the loading operation with a 4-man crew. (The sequence used is unknown to the authors). The 4-man crew might, then, be considered a good crew size to balance off speedy completion times while minimizing crew exposure topside. However, if downsizing of crews is a main consideration, the 3-man loading sequence would provide good performance as well. In this case, the CIWS training curriculum might be modified to incorporate the 3-man loading sequence presented in Figure 2.3.2.

```
                                 2-MAN ALLOCATION

                16.2                    44.8                 70.5     77.1    84.2     93.1
C1  +---------------+-----------------------+---------------------+-------+-------+---------+
          1                  2                       12             3       9        14

         7.8 10.8                       44.8                 70.5     77.1           91.3 93.1
C2  +-------+--+-------+                +---------------------+-------+--------------+ +
       10     11  13                                     12             3        4

 93.1            110.7                  131    138.2 141.6    155.8         170           184.5
C1  +---------------+-----------------------+--+-----+--+----------+-------------+--------------+
           15               16              17  18   19      5           6             7

 93.1            110.7                  131     141.5                                176.4    185.9
C2  +---------------+--------------------+     +--+------------------------------------+---+-------+
           15               16                  19                20                 21      22

 184.2          198.0    209.5  214.0    223.9    235.8     245.7     257.6     267.5
C1  +-------------+       +------+---------+       +-----------+         +----------+
          8                   28       29                30                   31

   185.9         202.1        214.0    223.9    235.8      245.7      257.6     267.5     279.4
C2   +---------------+------------+-------+-----------+-----------+----------+---------+----------+
           23              23a        29        24          30         25         31         26

 279.4      289.3       301.2    311.1  313.3          333.8  336.5  342.2  351.1
C1  +-----------+         +----------+--+                +---+------+---------+
          32                  33     34                   38     39       40

 279.4      289.3       301.2    311.1  313.3    324.8  330.1   336.5  342.2  351.1
C2  +-----------+-----------+----------+  +------------+-----+-------+    +----------+
          32          27          33            35          36     37           40
```

Figure 2.3.1 CIWS Loading Operation: 2-man Allocation

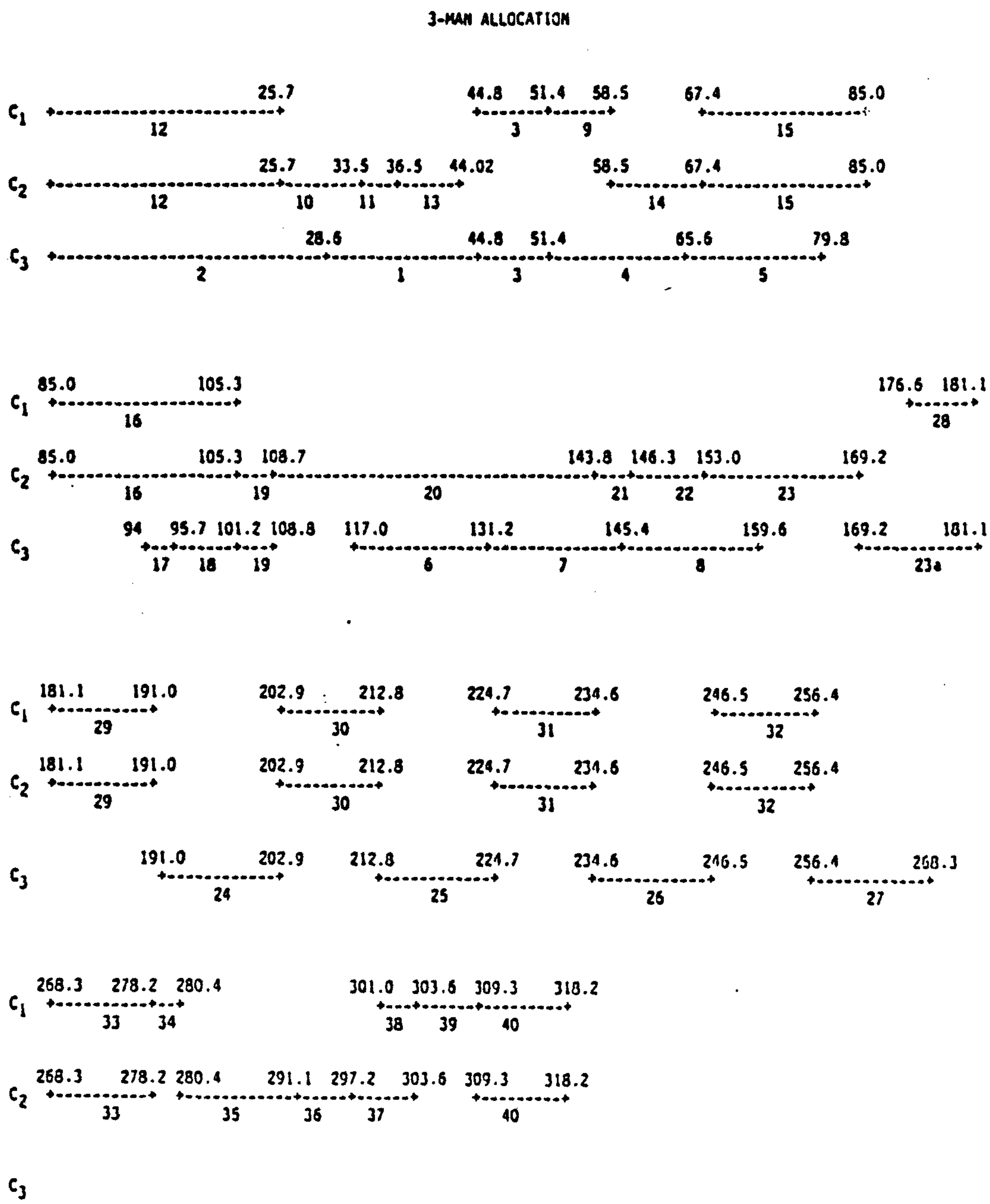


Figure 2.3.2 CIWS Loading Operation: 3-man Allocation.

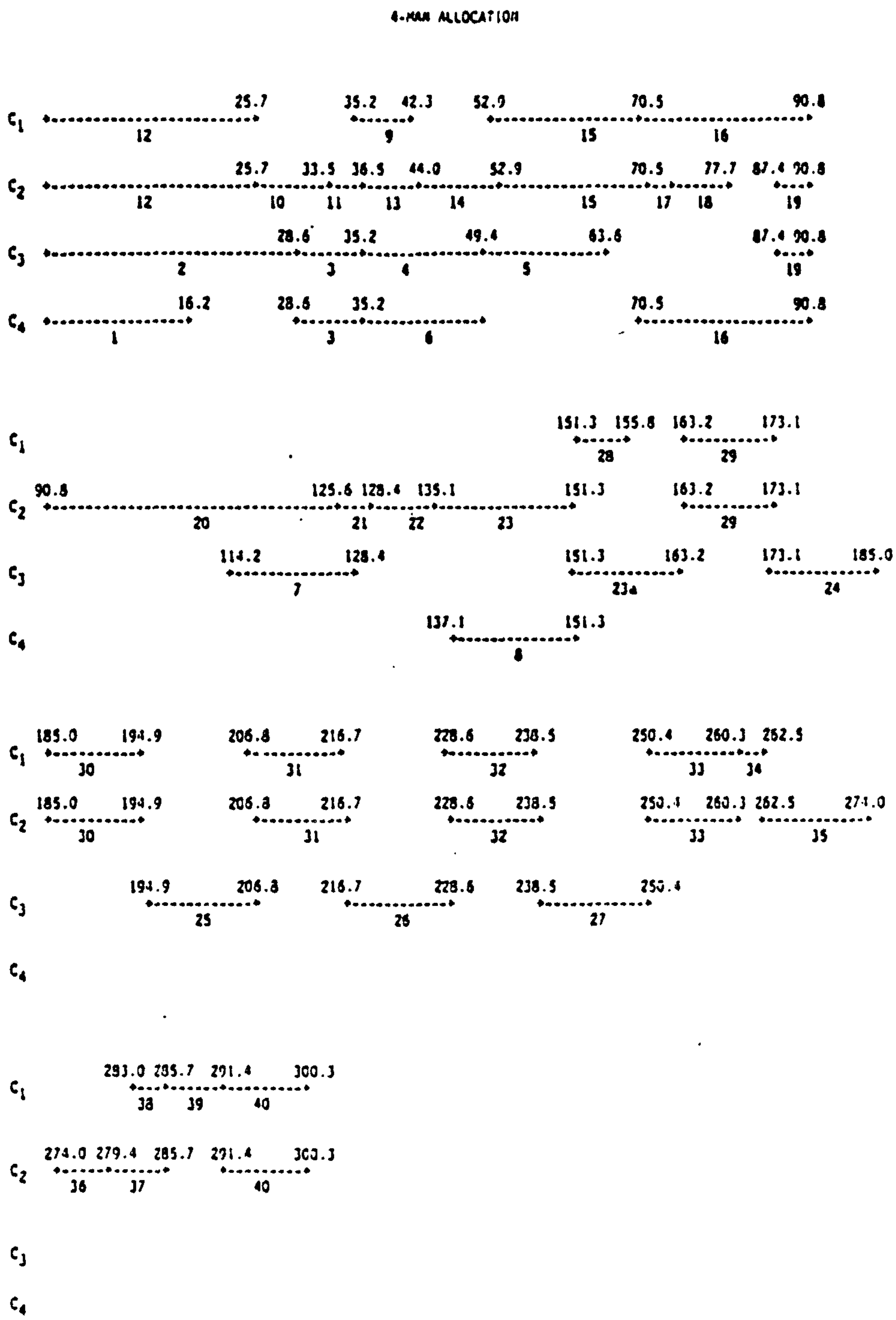


Figure 2.3.3 CIWS Loading Operation: 4-man Allocation.

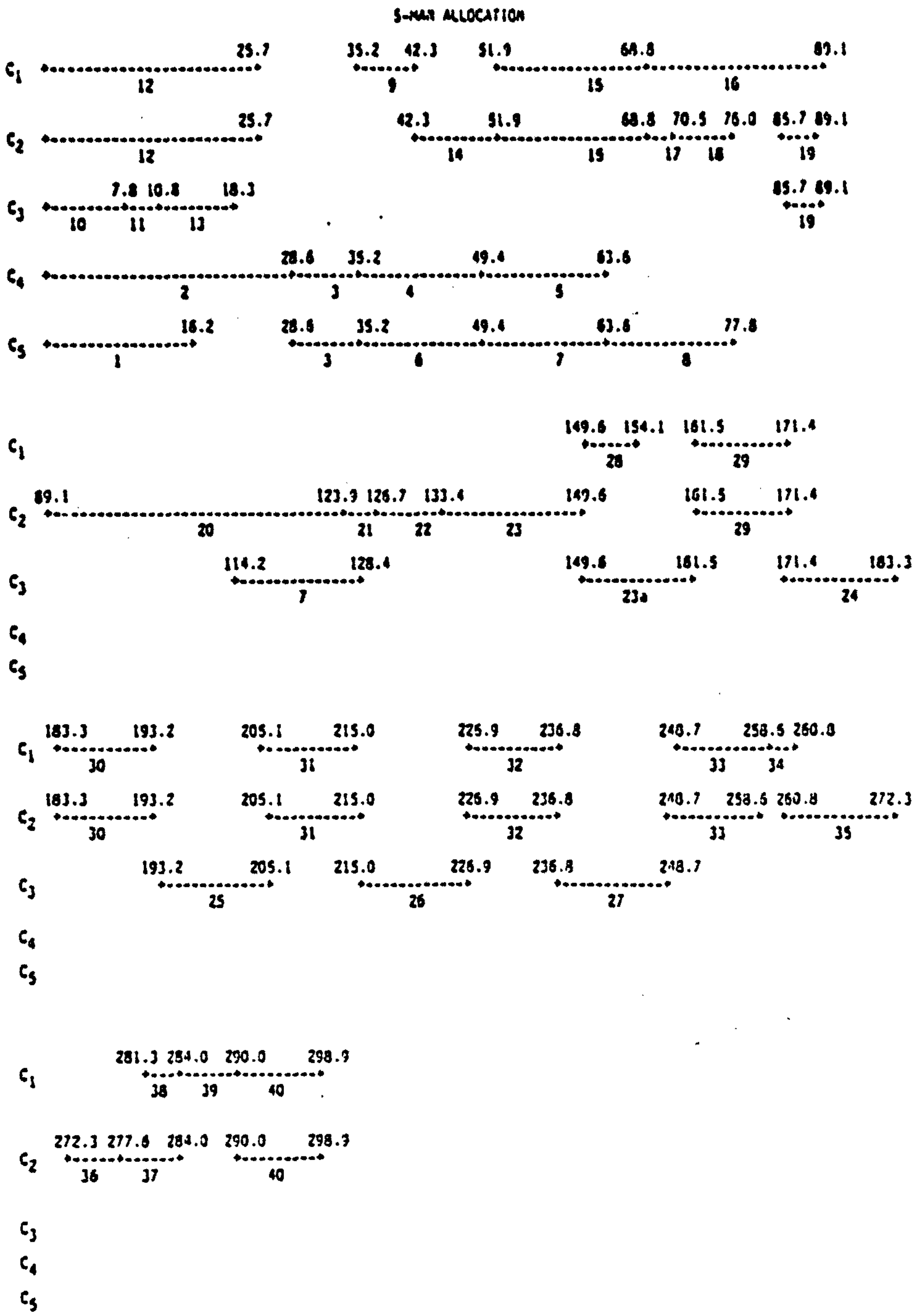


Figure 2.3.4 CIWS Loading Operation: 5-man Allocation.

Table 2.3.1. Comparison of GREEDY Heuristic and Optimal Results, Sample Networks.

Crew Size Solution	GREEDY Solution	OPTIMAL
2	337.93	335.43
2 Alt.	327.23	327.23
3	283.71	257.61
4	233.71	233.71
5	233.71	226.81

Table 2.3.2 Micro SAINT Model Results.

Total Completion Time (unit=seconds)

	5th Percentile	50th Percentile	95th Percentile
Baseline	242	299	356
2-man	274	348	422
3-man	252	317	381
4-man	239	309	378
5-man	248	300	352

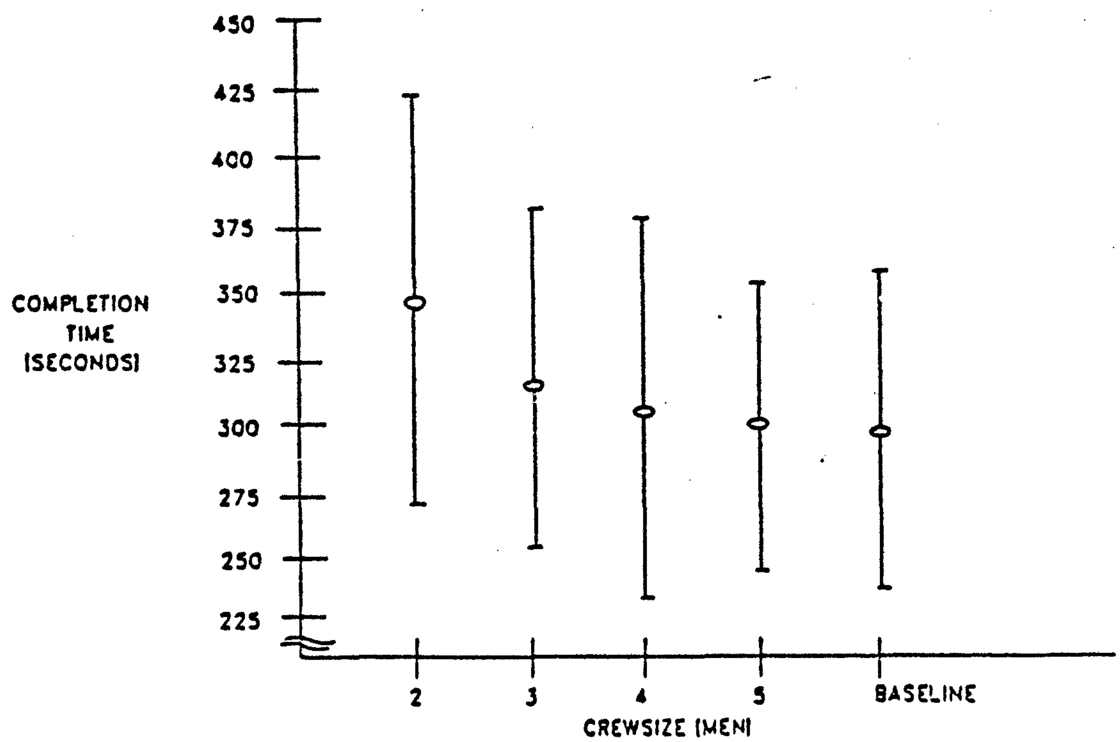


Figure 2.3.5 95% Confidence Intervals for Completion Times with Different Crew Sizes.

2.4 Discussion

The usefulness of Micro SAINT models was investigated by attempting to determine the impact of crew size and procedure on loading times. Thus, the research questions posed were:

1) Can existing models of a 3-man loading operation be manipulated in the laboratory to assess the impact of different crew sizes?

2) What is involved in manipulating models, i.e., what assumptions are required to develop these alternatives?

3) Can the manipulated models indicate procedures, for a given crew size, that are, if not optimal, at least as good as any other procedure which might be applied (based on minimizing completion time)?

This project demonstrated that it is possible to manipulate existing models of a real-world operation to assess operationally relevant questions about procedures and manning. From an operational standpoint, a decision maker may use such results to decide on the costs (e.g., exposure of crew) and benefits (e.g., reduced loading time) associated with adding crew to this critical operation; similarly, the results can provide the commander with the implications (on loading time) of loading crew casualties or downsizing. The results of this work can also have utility in terms of training. Specifically, an 'optimal' crew size and procedure might be arrived at in a reasoned fashion which can then be recommended for training purposes.

The answer to the second question is that, in order to manipulate the original CIWS models to assess the effects of alternative manning and procedures, many assumptions were made. The original models were taken apart and combined as needed to arrive at the revised manning and procedures. To do this, one must adopt strong system decomposition assumptions. In particular, it was necessary to assume additivity of activity elements; the completion time of an activity element is assumed independent of its predecessor(s) and its successor tasks. In some instances, data had to be synthesized. One had to assume that the population of loading crews was homogenous and the two crews for which empirical data were available could be pooled. Additionally, it must be assumed that the completion time data in the models are representative of the completion times which would be found in the Fleet. The degree to which these assumptions will support the conclusions drawn from the models remains to be seen from attempts to use them. In follow-on activities, attempts should be made to externally validate and refine the models as needed to provide human factors inputs to manning and procedures for this weapon system.

The answer to the third question is that Micro SAINT needed to be augmented by additional tools in order to arrive at "optimal" procedures. The GREEDY scheduling heuristic was developed to provide a reasoned approach to manning and procedural enhancements by considering the CIWS loading operation as a problem in scheduling. With regard to the GREEDY scheduling heuristic, several possibilities exist to expanding its use in a human factors engineering context. A task-crew allocation method would be of high value not only to the current project but for more general use as well. If this method can be developed, studied, and refined, it can be developed into a software product which helps solve an important class of human factors engineering problems i.e., manning.

A heuristic, once defined to handle a range of problems, should be subject to testing to determine its properties and would be improved upon as needed. Once the heuristic is finalized, it can be packaged as a computer program which accepts, as inputs, a precedence table of tasks, their predecessors, their completion time statistics, and their manpower requirements. This heuristic program could also be refined to represent different abilities or skill levels among crew members and the location constraints involved in a task conducted over a relatively large space. The output would be a Gannt chart (or some other suitable graphical representation) of the solution to the task allocation problem. This output could then be used as the starting point for Micro SAINT simulation work, e.g., to evaluate the distribution of completion times for this operation, to uncover bottlenecks which might be alleviated by engineering changes, etc. The only related human factors tool the authors are aware of is the Workstation Assessor for Crew Operations (WOSTAS), reported by Pulat and Pulat (1985). They describe WOSTAS as a heuristic computerized model which uses assembly line balancing concepts to generate alternative scheduling schemes of tasks to workstations. WOSTAS does handle different abilities among those individuals at the workstations and it also incorporates a tiring constraint which attempts to equalize the degree of effort which must be exerted at each workstation. The authors have not worked with WOSTAS; the relative effectiveness of its heuristic relative to GREEDY, as well as its ability to handle different manpower requirements (number of men required) per task, are unknown. Furthermore, it is not clear how easy it would be to have WOSTAS provide the kinds of outputs indicated above, though this merits further inquiry.

SECTION 3.0

TASK 2. Prediction of MOPP IV Impacts on CIWS Loading Using Data from a Pre-Existing Human Performance Database

3.1 Background

Troop performance degradation due to chemical protective equipment has been of increasing concern to military commanders. This protective equipment is worn in one of four configurations referred to as Mission Oriented Protective Posture (MOPP) levels. MOPP IV posture, during which all equipment is worn and sealed, is the most protective, and the most bulky, cumbersome and restrictive mode. Personnel are protected at the expense of their encumbrance, a circumstance which results from impeded functions such as vision, hearing, speaking, manual dexterity and others. This encumbrance produces degradation in the form of (usually) increased time to complete tasks and in some cases reduced accuracy. Furthermore, time on duty can be significantly reduced, depending on severity, intensity, and frequency of duty tasks due to heat stress.

Currently, significant efforts are being put toward the development of human performance databases for design, manpower and personnel integration, and training applications. (cf. Berquist and Guthals, 1991). In particular, a database of MOPP IV Task Time Multipliers (TTMs) has been compiled by the U.S. Army Ballistics Research Laboratory (BRL). This database has, as records, various army and air force operations and maintenance tasks which were performed in standard issue (shirtsleeve) clothing and in the MOPP IV Individual Protective Ensemble (MOPP IV IPE). The TTM measure for a particular record is the time to complete the task in MOPP IV IPE over the time to perform in shirtsleeves. The TTM measure is, then, a ratio which provides a multiplier for normal shirtsleeve completion times with which to gauge increased time to perform in the CBR-D environment. This database was identified for this study because it was reported to have indexed tasks not only by system-level descriptors (e.g., "Assemble ant. reflector on HAWK"), but also by a taxonomy of human performance, specifically the Fleishman taxonomy of human abilities (Fleishman and Quaintance, 1984).

One purpose of models is to allow a user to play "what if...". to assess situations for which empirical data collection is either difficult or infeasible. In this regard, the Micro SAINT models developed for the CIWS loading operation might be manipulated to assess the impact of MOPP IV IPE. This manipulation might indicate the range of completion times a commander could expect the loading operation to take under MOPP IV settings. The suitably configured models could also shed light on the locus of MOPP IV effects i.e., what types of activities are most affected by MOPP IV IPE. This is particularly interesting since the degrading effects of MOPP IV IPE have been inconsistently demonstrated. Some activities are heavily impacted by the encumbrance of MOPP IV while others are not affected at all (at least in terms of completion time). However, in order to use the Micro SAINT models for this purpose, additional data was necessary.

The purpose of this task was to investigate the use of an existing database not specifically developed for the CIWS models, to support assessment of MOPP IV degradation on CIWS weapon loading. From a human factors research and methodologies perspective, it also allowed for an investigation

into the use of archival human performance data to feed sequential network models developed in a different, though related domain.

3.2 Method

(Note: Since the start of this effort, the BRL database has been renamed for the Physiological and Psychological Effects of the Nuclear Biological, and Chemical Environment and Sustained Operations on Systems in Combat (P^2NBC^2) Program. Hereafter, all references will be to the BRL/P^2NBC^2 database.)

The initial difficulty encountered was to identify commonality across BRL/P^2NBC^2 database records and CIWS loading operation activity elements. System level descriptors are virtually useless in this regard. For example, the present authors are quite familiar with the Close-in Weapon System loading activity element "Mount autoloader". On the other hand, we know very little about the Army M109 task "Install firing mechanism" and how it might relate to CIWS weapon loading. A common language is needed which captures underlying similarities and dissimilarities among tasks.

Fleishman's taxonomy of human abilities (Fleishman and Quaintance, 1984) offers a common language with which to relate CIWS tasks and Army tasks. It was our understanding at the outset of this project that the BRL/P^2NBC^2 database indexed army tasks by means of human abilities. Therefore, the present authors set out to characterize the CIWS loading operation's activity elements with Fleishman's human abilities taxonomy. With this completed, we felt confident that it would be feasible to extract TTMs from the BRL/P^2NBC^2 database with which to modify the existing CIWS Micro SAINT models. The human abilities assessment methodology used on the CIWS loading operation tasks is described below.

Fleishman's taxonomy of human abilities consists of 52 individual abilities identified through a long and careful program of research (see Table 3.2.1). Each human ability has been carefully defined and these definitions, along with two other tools, were used to characterize the CIWS activity elements. In addition to the ability definition, Fleishman has constructed behaviorally anchored ability rating scales for each ability. For example, Figure 3.2.1 presents a human abilities assessment tool prepared by Fleishman and his colleagues which defines the human ability Verbal Comprehension (Fleishman and Quaintance, 1984) and contrasts it with other selected human abilities which might be confused with it. The rating scale, in turn, provides a criticality index with concrete behavioral anchors indicating scale values for specific behaviors. The analyst is instructed to first consider whether the given human ability is needed or not needed to perform the task (Fleishman, 1990). If the analyst assesses that at least some minimum amount of the ability is needed, then he uses the rating scale to decide how critical the human ability is to the task or job. It is stressed that the analyst consider only how important the given human ability is to the task being analyzed, not how easy or difficult it might be to perform. In this way, the rating scale is intended to capture invariant aspects of criticality to the task rather than difficulty, an attribute expected to vary among people with differing skill who perform the same task. The behavioral anchors are intended to help the analyst by providing concrete tasks which have been given stable ratings on the 7-point scale provided.

A second aid for human abilities assessment used in the current study was a decision flow diagram reported in Mallamad, Levine, and Fleishman (1980). Table 3.2.2 (Levine, 1990) presents a portion

Table 3.2.1 Fleishman Taxonomy of Human Abilities (Source: Fleishman and Quaintance, 1984)

1. Oral Comprehension	27. Finger Dexterity
2. Written Comprehension	28. Wrist–Finger Speed
3. Oral Expression	29. Speed of Limb Movement
4. Written Expression	30. Selective Attention
5. Fluency of Ideas	31. Time Sharing
6. Originality	32. Static Strength
7. Memorization	33. Explosive Strength
8. Problem Sensitivity	34. Dynamic Strength
9. Mathematical Reasoning	35. Trunk Strength
10. Number Facility	36. Extent Flexibility
11. Deductive Reasoning	37. Dynamic Flexibility
12. Inductive Reasoning	38. Gross Body Coordination
13. Information Ordering	39. Gross Body Equilibrium
14. Category Flexibility	40. Stamina
15. Speed of Closure	41. Near Vision
16. Flexibility of Closure	42. Far Vision
17. Spatial Orientation	43. Visual Color Discrimination
18. Visualization	44. Night Vision
19. Perceptual Speed	45. Peripheral Vision
20. Control Precision	46. Depth Perception
21. Multilimb Coordination	47. Glare Sensitivity
22. Response Orientation	48. General Hearing
23. Rate Control	49. Auditory Attention
24. Reaction Time	50. Sound Localization
25. Arm–Hand Steadiness	51. Speech Hearing
26. Manual Dexterity	52. Speech Clarity

VERBAL COMPREHENSION

This is the ability to understand English words and sentences.

How Verbal Comprehension Is Different From Other Abilities

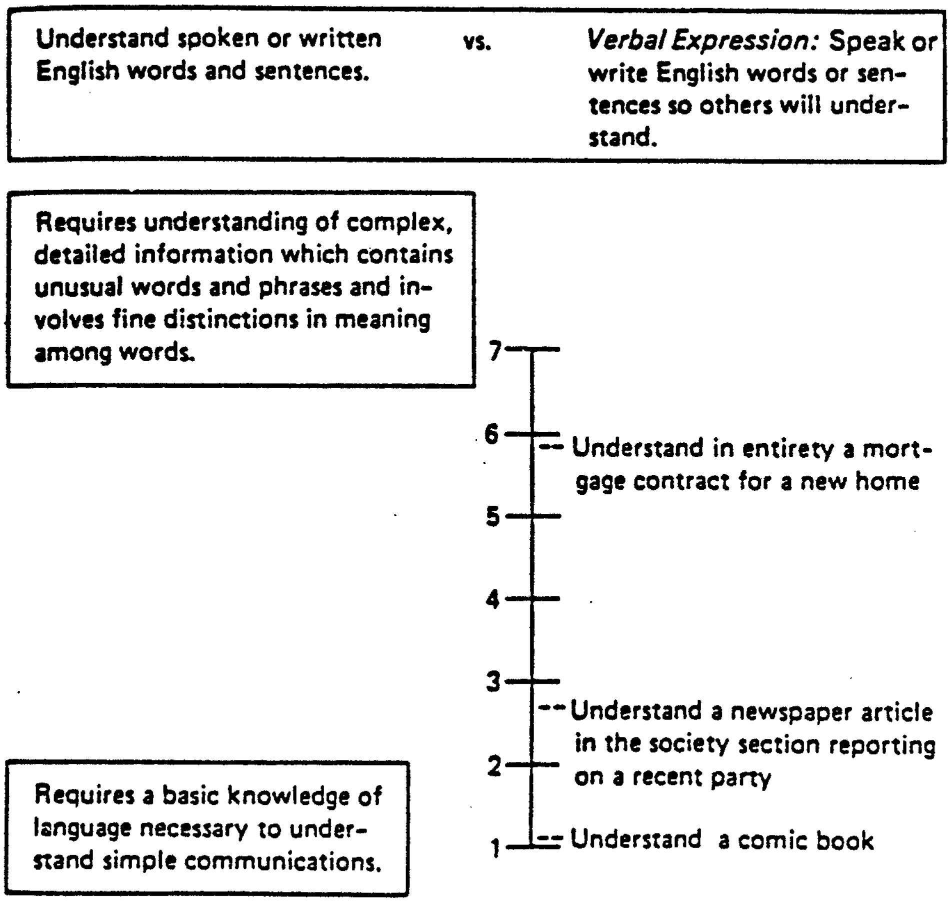
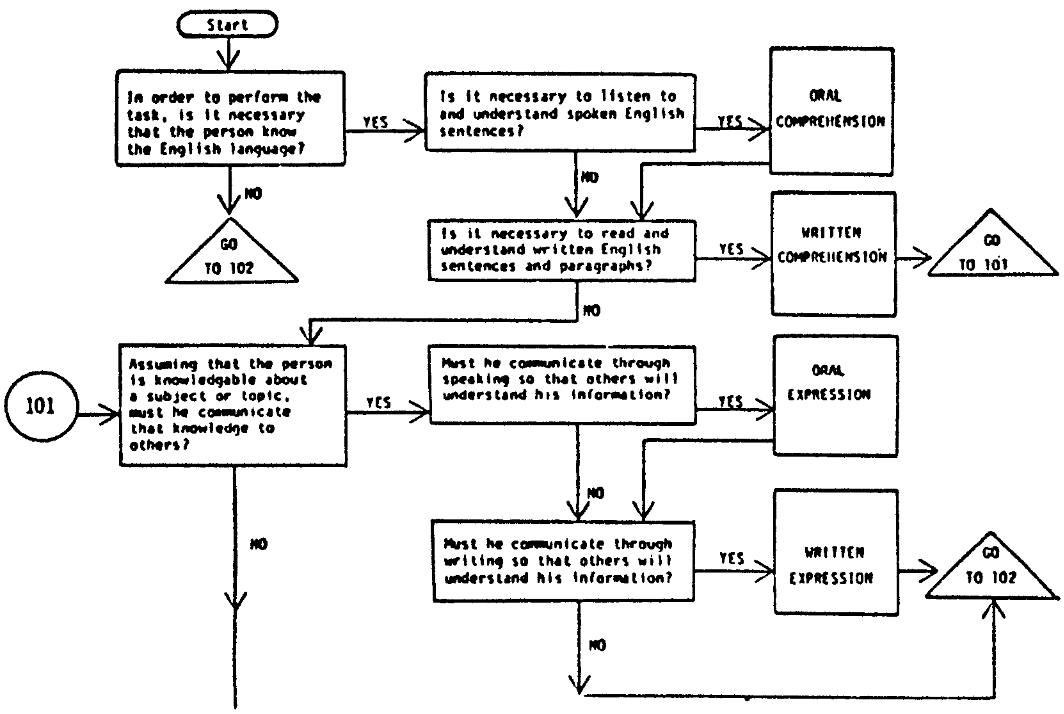


Figure 3.2.1 Ability Definition and Ability Rating Scale (Source: Fleishman and Quaintance, 1984).

Table 3.2.2 Ability Decision Flow Diagram (Source: Levine, 1990).



of the decision flow diagram which addresses Oral Comprehension (among other human abilities). The analyst follows the diagram and makes his way through it by a series of YES-NO decisions. Taken together, the definitions, behaviorally anchored rating scales, and decision flow diagrams were thought to provide a feasible technology to establish the human abilities required of CIWS loading operation task elements. Unfortunately, these tools are not readily available in the open literature; the authors acquired the necessary materials by contacting Drs. Fleishman and Levine directly. However, the Manual of Ability Requirement Scales (MARS) (Fleishman, 1990) is due to be published sometime in 1991. The publication of this volume will significantly increase the feasibility of the human factors community making greater use of this important taxonomy (See also Section 4.0).

3.3 Results and Discussion

The results of the human abilities assessment of CIWS loading operation activity elements are provided in Table 3.3.1. Because the CIWS loading operation is largely a manual task, physical human abilities predominate. In the process of using the Fleishman taxonomy and support tools, the following observations were made. An initial assumption about the activity elements was needed, i.e., that they represented errorless performance. This was in keeping with the data used in the CIWS models and it eliminated certain 'problem solving' abilities which normally are not needed for this operation. Furthermore, there is an inherent difficulty in the use of Fleishman's taxonomy with regard to thresholds. Many human activities make use of minimal levels of many human abilities. For example, in the task of typing th' report, there is a least a minimal ability of Gross Body Equilibrium required; however, one would not ordinarily consider this an ability required of word processing. Thus, it was sometimes difficult to know explicitly if the minimum threshold set for the NEEDED or NOT NEEDED discrimination was being consistently held.

Some additional observations on the process of human abilities assessment are also offered here. First, certain apparent inconsistencies in the rating scales were identified. For example, one anchor for Manual Dexterity was to "tie a necktie" with a mean rating of 2.3 while a very similar anchor was used for Finger Dexterity, "untie a knot in a package" with a mean rating of 3.4. Second, the environmental performance shaping factor of ship motion was assumed to be stable and calm. This is important because the criticality rating of an ability like Gross Body Equilibrium depends very much on sea state. Third, in some instances the behavioral anchor was unknown to the analyst, e.g., "cut and mount color film transparencies". Perhaps this is an individual deficiency but other anchors like "In a spacecraft out of control, quickly choose one out of 5 possible corrections in .7 seconds" surely could only be appreciated as a Gedanken experiment by the average person. Fourth, Fleishman's direction to use only whole number ratings may lead to some loss in criticality information which might otherwise be captured. Finally, the aids imply some abilities are mutually exclusive (e.g., stamina and static strength) but in real life both can be involved in the same task. These phenomena introduce variability into the assessments, we believe.

The human abilities taxonomy used in the BRL/P^2NBC^2 database is given in Table 3.3.2. It makes use of 42 of the same human abilities as the Fleishman taxonomy but it groups them into 10 higher-order ability categories. Furthermore, the developers of the database did not use the support tools described above. Instead, a 5-point criticality scale (ranging from "not important" to "very important") was devised. It is not behaviorally anchored and it's relationship to the Fleishman rating scales is unclear. In addition, the 10 higher-order human abilities categories were often used to

TABLE 3.3.1 Human Abilities Assessment of CIWS Loading Operation Activity Elements

ACTIVITY ELEMENTS

UNLOCK DOORS [1]	UNDO DOGS [2]	OPEN DOOR [3]	MOVE BOX [4]	MOVE LOADER [9]
Spatial Orientation (1)	Control Precision (1)	Spatial Orientation (1)	Spatial Orientation (2)	Spatial Orientation (2)
Multilimb Coordination (2)	Multilimb Coordination (2)	Manual Dexterity (1)	Manual Dexterity (2)	Manual Dexterity (2)
Arm-Hand Steadiness (1)	Manual Dexterity (2)	Static Strength (3)	Finger Dexterity (1)	Finger Dexterity (1)
Manual Dexterity (2)	Wrist-Finger Speed (2)	Gross Body Coordination (1)	Static Strength (5)	Static Strength (4)
Finger Dexterity (1)	Static Strength (1)		Extent Flexibility (2)	Extent Flexibility (2)
Wrist-Finger Dexterity (1)	Dynamic Strength (1)		Dynamic Flexibility (2)	Gross Body Coordination (2)
Speed of Limb Movement (1)	Extent Flexibility (1)		Gross Body Coordination (2)	Peripheral Vision (1)
Dynamic Strength (1)	Near Vision (1)		Stamina (1)	Depth Perception (1)
Extent Flexibility (1)			Peripheral Vision (1)	
Near Vision (2)			Depth Perception (1)	

NOTE: Numbers in brackets are activity element numbers. Numbers in parentheses are criticality ratings on a 7-point scale.

TABLE 3.3.1 Human Abilities Assessment of CIWS Loading Operation Activity Elements (cont.)

ACTIVITY ELEMENTS

REMOVE PINS [10]	STOW SHIELD [11]	TIME DRUM [12]	OPEN R LATCH [13]	POSITION LOADER [14]
Arm-Hand Steadiness (1)	Spatial Orientation (1)	Finger Dexterity (1)	Multilimb Coordination (1)	Flexibility of Closure ( )
Manual Dexterity (1)	Manual Dexterity (1)	Gross Body Equilibrium (3)	Arm-Hand Steadiness (1)	Spatial Orientation (2)
Finger Dexterity (1)	Extent Flexibility (1)		Manual Dexterity (2)	Multilimb Coordination (1)
Gross Body Equilibrium (3)	Gross Body Equilibrium (3)		Finger Dexterity (1)	Arm-Hand Steadiness (1)
Near Vision (1)	Peripheral Vision (1)		Gross Body Equilibrium (3)	Manual Dexterity (1)
			Near Vision (2)	Static Strength (3)
			Depth Perception (1)	Gross Body Equilibrium (3)

NOTE: Numbers in brackets are activity element numbers. Numbers in parentheses are criticality ratings on a 7-point scale.

TABLE 3.3.1 Human Abilities Assessment of CIWS Loading Operation Activity Elements (cont.)

ACTIVITY ELEMENTS

SECURE LOADER [15]	ALIGN L's & R's [16]	RELEASE TRAY [17]	LIFT & FASTEN TRAY [18]	HAND OFF BELT [19]
Multilimb Coordination ( )	Flexibility of Closure ( )	Arm-Hand Steadiness (1)	Multilimb Coordination (1)	Spatial Orientation (2)
Arm-Hand Steadiness (1)	Perceptual Speed (1)	Manual Dexterity (1)	Arm-Hand Steadiness (1)	Multilimb Coordination (1)
Manual Dexterity (1)	Extent Flexibility (2)	Finger Dexterity (1)	Manual Dexterity (1)	Arm-Hand Steadiness (1)
Finger Dexterity (2)	Gross Body Equilibrium (3)	Gross Body Equilibrium (3)	Finger Dexterity (1)	Manual Dexterity (1)
Gross Body Equilibrium (3)	Near Vision (3)	Near Vision (1)	Gross Body Equilibrium (3)	Finger Dexterity (1)
Near Vision (1)			Near Vision (1)	Extent Flexibility (1)
Depth Perception (2)				Gross Body Equilibrium (3)

NOTE: Numbers in brackets are activity element numbers. Numbers in parentheses are criticality ratings on a 7-point scale.

TABLE 3.3.1 Human Abilities Assessment of CIWS Loading Operation Activity Elements (cont.)

ACTIVITY ELEMENTS

START BELT END [20]	LOWER LOADER TRAY [21]	LOCK TRAY [22]	FINISH BELT POSITION [23]	CLIP BELT ENDS [24-27]
Flexibility of Closure (3)	Multilimb Coordination (1)	Arm-Hand Steadiness (1)	Control Precision (2)	Flexibility of Closure (3)
Multilimb Coordination (1)	Arm-Hand Steadiness (1)	Manual Dexterity (1)	Multilimb Coordination (1)	Multilimb Coordination (2)
Arm-Hand Steadiness (1)	Manual Dexterity (1)	Finger Dexterity (1)	Gross Body Equilibrium (3)	Arm-Hand Steadiness (1)
Manual Dexterity (1)	Finger Dexterity (1)	Gross Body Equilibrium (3)		Manual Dexterity (2)
Gross Body Equilibrium (3)	Gross Body Equilibrium (3)	Near Vision (1)		Gross Body Equilibrium (3)
Near Vision (2)	Near Vision (1)			Near Vision (2)

NOTE: Numbers in brackets are activity element numbers. Numbers in parentheses are criticality ratings on a 7-point scale.

TABLE 3.3.1 Human Abilities Assessment of CIWS Loading Operation Activity Elements (cont.)

ACTIVITY ELEMENTS

ACTIVATE HYDRAULICS [28]	UPLOAD ROUNDS [29-33]	DEACTIVATE HYDRAULICS [34]	REMOVE FASTENERS [35]	LIFT OFF LOADER [36]
Spatial Orientation (2)	Spatial Orientation (1)	Spatial Orientation (2)	Manual Dexterity (1)	Multilimb Coordination ( )
Perceptual Speed (1)	Control Precision (2)	Control Precision (1)	Finger Dexterity (1)	Manual Dexterity (2)
Arm-Hand Steadiness (1)	Gross Body Equilibrium (3)	Arm-Hand Steadiness (1)	Extent Flexibility (1)	Finger Dexterity (1)
Finger Dexterity (1)		Finger Dexterity (1)	Gross Body Equilibrium (3)	Static Strength ( )
Extent Flexibility (2)		Extent Flexibility (2)	Near Vision (1)	Dynamic Strength (3)
Gross Body Equilibrium (3)		Gross Body Equilibrium (3)		Extent Flexibility (1)
				Gross Body Coordination (1)
				Gross Body Equilibrium (3)
				Near Vision (1)

NOTE: Numbers in brackets are activity element numbers. Numbers in parentheses are criticality ratings on a 7-point scale.

TABLE 3.3.1 Human Abilities Assessment of CIWS Loading Operation Activity Elements (cont.)

ACTIVITY ELEMENTS

SECURE ROUNDS LATCH [37]	GRASP SHIELD [38]	POSITION SHIELD [39]	FASTEN SHIELD [40]
Arm-Hand Steadiness (1)	Spatial Orientation (1)	Speed of Closure (1)	Arm-Hand Steadiness (1)
Manual Dexterity (1)	Arm-Hand Steadiness (1)	Arm-Hand Steadiness (1)	Manual Dexterity (1)
Finger Dexterity (1)	Manual Dexterity (1)	Manual Dexterity (1)	Finger Dexterity (1)
Gross Body Equilibrium (3)	Finger Dexterity (1)	Finger Dexterity (1)	Gross Body Equilibrium (3)
Near Vision (2)	Extent Flexibility (1)	Dynamic Strength (1)	Near Vision (2)
	Gross Body Coordination (1)	Gross Body Equilibrium (3)	
	Gross Body Equilibrium (3)	Near Vision (1)	
	Peripheral Vision (1)		

NOTE: Numbers in brackets are activity element numbers. Numbers in parentheses are criticality ratings on a 7-point scale.

TABLE 3.3.2 BRL/P²NBC² Database Human Abilities Taxonomy.

Human Ability Codes	Human Sub-Ability Codes
COM = Communication	A01 = Speech Comprehension A02 = Reading Comprehension A03 = Speech Expression A04 = Written Expression A05 = Auditory Attention A06 = Speech Clarity
NUM = Numerical Ability	A07 = Memorization A08 = Number Facility
CON = Decision Making	A09 = Problem Sensitivity A10 = Deductive Reasoning A11 = Inductive Reasoning A12 = Information Ordering
PER = Precision Control Skills	A13 = Manual Dexterity A14 = Finger Dexterity A15 = Wrist-Finger Speed
MOV = Movement and Coordination	A16 = Extent Flexibility A17 = Dynamic Flexibility A18 = Gross Body Coordination A19 = Gross Body Equilibrium
ATT = Attention and Quickness	A20 = Reaction Time A21 = Speed of Limb Movement A22 = Selective Attention A23 = Divided Attention
VIN = Visual Pattern Recognition	A24 = Speed of Closure A25 = Flexibility of Closure A26 = Spatial Orientation A27 = Visualization A28 = Perceptual Speed
MAN = Manual Control	A29 = Control Precision A30 = Multi-Limb Coordination A31 = Rate Control A32 = Arm-Hand Steadiness
STR = Strength and Stamina	A33 = Stamina A34 = Static Strength A35 = Explosive Strength A36 = Dynamic Strength A37 = Trunk Strength
VIS = Vision	A38 = Near Vision A39 = Far Vision A40 = Color Discrimination A41 = Night Vision A42 = Peripheral Vision

characterize the tasks in the database. Perhaps most problematic of all is the fact that the database records do not contain a full characterization of each task in terms of human abilities. Instead, a task was characterized as predominantly being of a single human abilities category. Since any task almost invariably involves multiple human abilities for its successful completion, the indexing of database tasks by means of a single ability renders use of the database for CIWS Micro SAINT modeling infeasible. However the BRL/P^2NBC^2 database does have a mechanism by which Task-Time Multipliers might be synthesized. The database offers a prototype procedure which takes a profile of human abilities (weighted by their criticality or importance to the task), returns a synthesized Task Time Multiplier (TTM). This TTM is created by searching and averaging across all records with a given human ability. Then the application calculates a weighted average of all such mean TTMs, using the criticality or importance weightings input by the user, to provide a composite TTM for the task of interest.

When the authors first learned of the database, we were encouraged that Task 2 of the present study would indeed be feasible. Upon more in-depth investigation, however, this proved not to be the case. In particular, since the database only characterizes a database task by means of a single, most prominent, ability, any statistical means returned for TTM calculation would be misleading. In particular, this is because such means will under-represent the TTMs in the data base. By taking only TTMs associated with a subset of tasks which might use, e.g., the ability "verbal communication", a biased sample statistic is generated.

The authors had also hoped to model the BRL database TTMs by means of multiple human abilities (see Section 4.0 for a further discussion of modeling approaches for human performance databases). This also turned out to be infeasible because each task record in the BRL database was indexed by only a single human ability, not a set of abilities as anticipated.

Complicating matters further was the fact that the human ability for a database record was stored as a categorical variable. That is, a particular human ability was indicated as present but its criticality rating was not preserved. This meant that original intentions to model the TTMs by means of different levels of criticalities for even a single human ability could not be feasibly pursued.

Another difficulty associated with the use of an existing database to feed data to another model is one of granularity. In general, the analyst will know the level of decomposition for his task, i.e., task, subtask, activity element, etc. The coarseness of database data will not be immediately apparent because of the system level of description used for the database records. Thus, an analyst working with a human performance database will not necessarily know whether or not he is using task level data for an application to sub-task or activity element modeling. By using coarser grain size for database entries, more performance shaping factors are "hidden", and so may introduce bias into the extracted data. For instance, criticality ratings could be influenced by the proportion or frequency of time spent using a certain human ability and this is a function of the granularity of the database records.

In sum, then, the BRL/P^2NBC^2 database, while well suited for its originally intended purpose as a repository of field and laboratory tests and evaluations, could not support the CIWS modeling effort. Therefore, Section 4.0 will present a discussion of issues in human performance modeling from a taxonomic approach using human abilities as the main focus.

SECTION 4.0

GENERAL DISCUSSION AND SUMMARY

4.1 Introduction

Models help describe, predict, and control phenomena. Useful human performance models could be used to describe human-system interaction under alternative designs or operational postures (e.g., MOPP IV), predict the relationship between task features and performance, and give insights with which to enhance the human-system interface through procedural, engineering, manning, or training interventions. As a theory of human performance (Pew and Baron, 1983 point out that psychologists often treat models as theories), a model could be used to organize facts and orient a program of research.

Human performance models need data for their construction and use and human performance databases are one source of such data. In this section, a discussion of the various issues associated with the use of archival human performance data for modeling purposes is presented. Fleishman's human abilities taxonomy is referred to throughout this section because of the importance of a human performance taxonomy to database indexing and modeling. As perhaps the most developed human performance taxonomy available, it holds great potential for fulfilling a need in the human factors engineering profession which was noted in one of the earliest reviews of the field (Melton and Briggs, 1960) and one of the most recent (Gopher and Kimchi, 1989).

In this section, we will introduce a model of human performance, POET, which we believe holds promise in developing a better understanding of the human performance effects of environmental stressors such as MOPP IV Individual Protective Equipment (IPE). The criteria which a human performance taxonomy should ideally meet are provided and the human abilities approach is evaluated with respect to them. Approaches to using database output for quantitative human performance prediction are discussed. Finally, issues in information retrieval and search from a human performance database are introduced.

4.2 POET: A Model of Human Performance

The underlying assumptions behind the human abilities approach is that tasks require various mixes and levels of human abilities for their completion. Examples include manual dexterity, selective attention, stamina, and speech hearing. Therefore, human abilities offer one means of describing tasks with a common vocabulary. This suggests that human performance might be predicted by human abilities and the effects task and environmental factors have on performance might be understood in terms of the effects they have on human abilities.

Figure 4.2.1 depicts one model of how human abilities relate to performance. [Note: The term POET was first used by Farina and Wheaton (1973, cited in Fleishman and Quaintance, 1984). However, the model presented here is the present authors' own. Only the name has been borrowed and any additional similarities are incidental.] This model states that performance (P) is a function of the

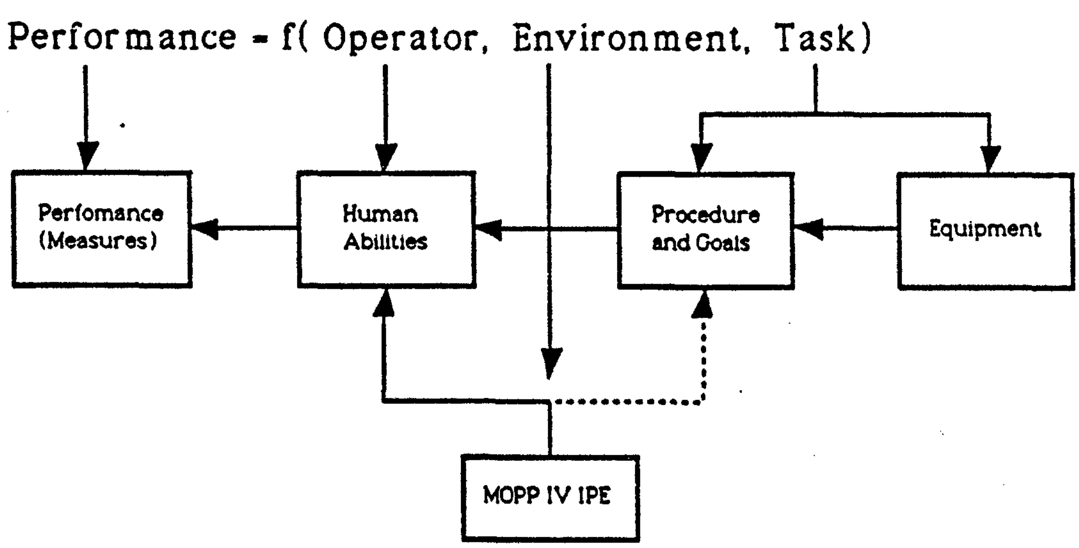


Figure 4.2.1 The POET Model.

operator (O), the environment (E), and the task (T). Performance is always captured by measures operationally defined to represent the target behavior of interest. Chapanis (1970) has pointed out some of the difficulties inherent in defining measures of performance. Specifically, he points out that measures such as reaction time, percent correct, and subjective ratings, often have only the loosest ties to such system-level criteria as "ease of use", "comfort", or "reliability". The search for valid performance measures is one which continues to occupy a central role in human factors research.

There are a variety of operator factors which might be identified. For present purposes, a central role is assumed to be played by human abilities, those relatively enduring attributes of the individual performing the task. Operator factors also include skill, i.e.,the level of task proficiency exhibited by an individual. Other operator factors which come into play during performance include physical capabilities and limitations, level of training, motivation, mood, various decision biases (e.g., speed-accuracy tradeoff, risk aversion, etc.), among others. A final operator factor worth mention here is task redefinition (Hackman, 1969). This refers to the degree to which an externally imposed task is subjectively redefined by the performer in terms consistent with his goals, values, needs, and understanding of the situation. Task redefinition is potentially problematic since it can significantly affect the way tasks are approached and the results obtained. However, Hackman (1969) points out that while objective and subjective tasks may occupy different points in time, they are both still tasks and should therefore be describable in the same terms. He goes on to explain that task redefinition is minimized in situations in which the performer understands the objective task, accepts the task and is willing to cooperate in its demands, has relatively few idiosyncratic needs and values, and has past experience or training consistent with others performing the same task.

The other two terms in the POET model are environmental factors and task factors. Environmental factors range from noise, lighting, climate, and motion parameters to the MOPP IV individual protective ensemble (IPE). Their characterization depends on the purposes the modeler has in mind. Task factors include equipment design, the procedures, and the goals attendant to the task. The characterization of tasks in taxonomic terms has been attempted several times (see Fleishman and Quaintance (1984) for examples). The Task Characteristics Approach (Farina and Wheaton, 1973, cited in Fleishman and Quaintance, 1984), for instance, represents tasks by describing task components like goals, responses, procedures, stimuli, and stimulus-response relationships. The task characteristics approach of Farina and Wheaton is particularly noteworthy in that task components are characterized by means of scales which have been successful in predicting actual task performance. See also Gavron, Drury, Czaja, and Wilkins (1989) for a more recent taxonomy of task variables intended to support human performance modeling in design.

The POET model postulates a particular relation among operator, environmental, and task factors. With regard to the task, it is hypothesized that equipment design (deployed within an organizational context) determines in large part the procedures and goals that the performer will use. Support for this assumption is given by recent work on human error. Perrow (1984) has made a distinction between 'tightly coupled' systems and 'loosely coupled' systems, for instance. Tightly coupled systems are those equipment designs which do not accommodate procedural variation. Loosely coupled systems, on the other hand, have equipment designs which allow for procedural variation, are tolerant of delays, and allow for some changes in the personnel and tools used. This suggests that equipment design significantly influences procedures.

It is assumed that the resulting allowable procedures, in turn, largely determine the human abilities required of a task. It is our belief that in a systems context people always perform tasks by means of procedures (albeit sometimes simple, informal, or inconsistent ones), a belief which stems from several sources. The first is an observation that system training and documentation (e.g., military operator's manuals like that prepared for the CIWS) describe equipment operations precisely with procedures which are to be followed. This assumption is also based on the work of Fleishman and his colleagues in linking task characteristics to human abilities (Fleishman, 1978; Fleishman and Quaintance, 1984). In studies of perceptual-motor performance, fault diagnosis, concept formation, and auditory detection and identification, Fleishman and his associates found systematic changes in both the mix and levels of abilities required with task modification. We believe these changes were brought about largely by changes in the procedures which the performers used in carrying out their tasks.

The influence of an environmental stressor such as MOPP IV IPE is hypothesized to manifest itself in two ways. The most powerful effect of the environment is assumed to be on the human abilities involved (indicated by the solid line in the accompanying Figure). This might involve a change in the required level of an ability or a mix of abilities needed, or both. For instance, MOPP IV gloves might increase the level of the ability "manual dexterity" required to link belts of rounds during CIWS loading. On the other hand, an environmental stressor like night operations might require a new mix of abilities not present during daytime operations , e.g., the addition of the ability "night vision".

The second way in which an environmental stressor like MOPP IV IPE manifests itself is in a change in procedures (indicated by the broken line in the accompanying Figure). Basically, the POET model acknowledges that environmental stressors like MOPP IV IPE might induce 'work-arounds'. The extent or circumstance under which this might happen are as yet unclear but certainly they will be dependent on the equipment design and the procedural variations which that design will tolerate. Of course, a change in procedure may entail a new mix of abilities and/or required abilities levels. These are questions to which a research program might be addressed.

4.3 Predictive Modeling with Taxonomic Descriptors

The approach which the authors had planned to take in Task 2 was as follows. First, for each CIWS loading operation activity element, the BRL/P^2NBC^2 database would be searched for records which matched it on the human abilities involved. From these matches, a Task Time Multiplier (TTM) would be computed. The TTM would then be used to modify the Micro SAINT completion time parameters for that activity element in the following way:

Activity Element Mean (revised) = TTM * OLDMEAN

Activity Element Var (revised) = TTM^2 * OLDVAR

In order to draw inferences from data contained in a human performance database, one must assume that the data were taken from a random sample from a representative population like the one to which the model using the data is directed. In the present case, it was assumed that the BRL/P^2NBC^2

database contained data on Army tasks with MOPP IV IPE effects similar to those which would apply to CIWS activity elements.

Given these assumptions, it is now possible to search the database for records which might be averaged over to arrive at mean task time multipliers (TTMs) for tasks with specific human abilities requirements. The means would represent the mean of the MOPP IV IPE encumbrance effect for that human ability. Thus, one possibility is to search for all records in the database which make use of a particular ability, average over them, and return the result. A more fine grained approach is to search for those database records which have the same human ability as the task of interest AND the same criticality rating, and only average over those. In either case, additivity of effects is assumed. That is, by taking means of database records on a single indexing term (i.e., a single human ability), it is assumed that there are no interaction effects across different mixes of human abilities.

A more sophisticated approach to developing to developing TTMs for CIWS loading operation activity elements would be to make use of whole sets of human abilities related to a task of interest. One could search for database records which matched exactly on abilities and use those records' TTM values but this is likely to return few if any records (see discussion in Section 4.5). Alternatively, one could compute means as described above and simply weight each mean TTM per human ability by the relative contribution (e.g., percentage of the time that ability is used) each is judged to make to the task and use this as a composite value. Such a simple model may have much to be said for it but its goodness of fit to the data is currently unknown. Finally, one might arrive at a TTM estimate for a task by constructing multiple regression equations of the form, for a first approximation:

$$TTM' = \beta_0 + \beta_1{*}HA_1 + \beta_2{*}HA_2 + \beta_3{*}HA_3 + \ldots + \epsilon$$

Where TTM' is the predicted TTM, β_i are regression weights, HA_i are relevant human abilities, and ϵ is an error term.

The goodness of fit to such a model would need to be assessed and other forms (quadratic terms, for instance) tried out systemically as appropriate. One advantage to using human abilities for such equations might be that, by the nature of their definitions and development in a factor analytic context, human abilities may be treated as orthogonal variables. Obviously, if only the presence of absence of a human ability is indicated in a human performance database record, the above model is composed completely of indicator variables. On the other hand, if criticality ratings are preserved in a database record, these can be treated as quantitative variables.

Whichever of the above formulations is applied, one must be aware that databases which serve as a repository for various field and laboratory data can legitimately be considered historical records or happenstance data. Box, Hunter, and Hunter (1980) discuss this problem and point out several possible dangers to which the analyst must be attuned. First, the data may be inconsistent; there may be significant differences in the way various data were collected, the subjects used, and so forth so that one risks mixing 'apples and oranges'. Second, there is no control over the range of variables represented in such a database. In the case of human abilities, for example, it may not be possible to model high criticality ratings because these are seldom used. Third, Box, et al. (1980) warn against the nonsense correlation. This is a correlation between, say, two variables which is actually caused by

a third, lurking variable which affects the process but either is not observed or is not even known to exist. Box, et al. conclude their discussion by pointing out that there are two ways to use regression equations. The first is to predict a response from passive observations of n trials. This can be done if it is assumed that the same correlative relationships that existed during the data collection period still operate when the predictions are being made. On the other hand, they point out, to intervene and change a system one needs causal relationship. To safely infer causality, the researcher cannot rely on natural happenings but rather must choose an experimental design and introduce randomization to break links with possible lurking variables. Since human performance databases are usually created with data from planned studies, perhaps the human factors community is on relatively safe ground. However, multiple studies deposited in the same database at different times by different sources may reduce the confidence we hold in this regard.

4.4 Criteria for Human Performance Taxonomies

Companion and Corso (1982) have identified a number of criteria that an 'ideal' taxonomy of human performance would meet. These criteria provide a useful framework for considering the merits of the human abilities taxonomy and will be so used. The assessment provided below is that of the authors and is not necessarily consistent with Companion and Corso's own assessment.

Criterion 1 states that the taxonomy must simplify descriptions of tasks in the system and thus make the subject matter of the taxonomy (in this case, human behavior in a systems context) more manageable. The human abilities taxonomy indeed offers a simplified description (via a vocabulary of 52 terms with which to describe virtually any human task). In this regard, it is worth noting that simplification generally comes at a price. Simplified description ignores other aspects of the task, aspects which are relegated to the realm of unaccounted-for variability. The problem is determining whether or not the task details which are ignored by the simplified description represent systematic structure which, in fact, shapes human performance.

Criterion 2 states that the taxonomy should be generalizable, otherwise it is a just system-specific task analysis. In the present case, the reason why we considered a human performance database purported to index human performance by human abilities was precisely because it offered a common vocabulary for describing both CIWS loading operation tasks and the tasks in the BRL/P^2NBC^2 database. Furthermore, 52 human abilities descriptors is significantly more parsimonious that the thousands of system-level task statements which one might encounter. Human performance data are commonly described by means of a system-specific language. For example, the present authors are quite familiar with the Close-in Weapon System loading task "Mount autoloader". On the other hand, we know very little about the Army M109 task "Install firing mechanism" and how it might relate to CIWS weapon loading. A common language is needed which captures underlying similarities and dissimilarities among tasks. Meister (1989) has pointed out that the most important use of taxonomies is to allow specialists to compare two or more tasks which were carried out under perhaps quite different contexts and determine if they are the same, highly related, or quite different. Fleishman's human abilities taxonomy provides one significant step toward making this comparison more readily. Human abilities form a necessary, if not sufficient, set of generally useful descriptors for human performance modeling, we believe.

Criterion 3 states that the taxonomy must employ terms which are compatible with the terms of the users. Companion and Corso (1982) argue that unless the taxonomy is in a form that is meaningful to those who would use it, its application will be inappropriate and often ignored. Meister (1989) reiterates this concern in his comment that, to have utility, a taxonomy should not require excessive training to make use of it. He goes on to say that if users find it difficult to differentiate one category from another or to assign empirical data to those categories, then the taxonomy is unreliable and will not be employed.

This criterion is a complex one to address because it encompasses issues of both familiarity and reliability. Consider familiarity first. On this point, we disagree with an extreme interpretation of this criterion, i.e., "chances are if the user doesn't already know it, he's probably not interested in learning it." Current training in behavioral science in general and human factors engineering in particular is lacking in task analysis and taxonomies of human performance. It is unreasonable to expect that something as rich and varied as human performance, broadly defined, is going to be accurately captured in the language of the "common man", to be scribbled on the back of an envelope while waiting for the bus! Just as learning statistical techniques for data analysis requires training and effort, so does learning a system to carefully and succinctly describe human tasks. One implication of this is that taxonomies like human abilities should be integrated into the training of human factors specialists and other behavioral scientists and engineers. In sum, then, the human abilities taxonomy is not yet compatible with prospective users but it could be learned.

A second, related issue revolves around how reliable the human abilities taxonomy is to employ. Various threats to the consistent and reliable characterization of tasks in terms of human abilities are dealt with in greater detail in Section 3.3 of this report. For the present, it is fair to say that Fleishman's human abilities taxonomy, if applied with the tools and decision aids developed for it (e.g., the MARS manual) does possess statistical reliability. It is the most sophisticated psychometrically developed taxonomy in existence. On the other hand, there are opportunities for improvement.

Criterion 4 states that the taxonomy must be complete and internally consistent. Fleishman's extensive factor-analytic work lends support that the human abilities taxonomy is both complete and internally consistent. To the extent that the human abilities identified to date are orthogonal to one another, they are independent and non-overlapping by definition. However, it is logically impossible to guarantee that any taxonomy will be complete; in principle, it is always possible to uncover a new task which requires a new taxonomic index. For example, it might turn out that new environmental parameters will need to be understood and entered into an environmental conditions taxonomy if that taxonomy is to be extended to the exotic setting of Mars.

Criterion 5 indicates that the taxonomy must be compatible with the theory or system to which it is applied. In the case of human abilities, the POET model represents a theory of how environmental stressors such as MOPP IV protective suits might manifest their effects on human performance. In this case, the human abilities taxonomy is compatible with research questions pursued within the POET theoretical framework. Since the assumption is that tasks in general (and CIWS loading tasks in particular) require various mixes and levels of human abilities for their completion, the human abilities taxonomy seems compatible with the system (CIWS weapon loading) to which it might be applied. The human abilities taxonomy also appears to be compatible with a simplified system of quantitative modeling, namely, additive models. This is true to the extent that the human abilities identified by Fleishman in his factor-analytic work are orthogonal to one another. In this case,

problems of multicollinearity disappear with orthogonal predictor variables. [Note, however, that the properties of a taxonomy are independent of issues of representativeness and random sampling of the data contained in a human performance database.]

Criterion 6 states that the taxonomy must provide some basis on which performance can be established or predicted. In this regard, Fleishman and Quaintance (1984) have presented numerous applications where the human abilities taxonomy has organized or established human performance effects in the literature. In particular, the human abilities taxonomy has been used to facilitate a better understanding of the vigilance literature, of assessing the effects of alcohol, drugs, and noise on human performance, and of supporting job classification and the setting of performance standards.

Criterion 7 states that the taxonomy must have some practical utility, either applied or theoretical. In our view, the human abilities taxonomy has great utility if such descriptors account for a non-negligible proportion of performance variability. Fleishman and Quaintance (1984) present evidence that this is indeed possible. The challenge is to extend this work further.

Criterion 8 states that the taxonomy must be cost-effective. Since issues of cost-effectiveness are relative to a particular application, no discussion of this criterion is offered here.

Criterion 9 states that the taxonomy must provide a framework around which all relevant empirical data can be integrated. Again, Fleishman's taxonomy shows promise in this area (see the related discussion of Criterion 6). However, the POET model of human performance suggests that it is likely that the human abilities approach will need to be augmented by a taxonomy of tasks and a taxonomy of environments in order to provide a comprehensive description of human performance. Other taxonomies may also be needed, e.g., a system taxonomy such as that suggested by Meister (1989). It would be profitable to identify overlap and redundancies among these taxonomies.

Criterion 10 says that the taxonomy should account for the interaction between task properties and operator performance. At present, human abilities associated with a task are determined by an analyst. There is presently no formal conversion routine which takes task descriptors as inputs and generates requisite human abilities as outputs. However, Fleishman (1978) reports on studies which demonstrate that task characteristics do influence the mix and levels of human abilities required. The paradigm was to develop "criterion tasks" (tasks of interest) and administer these to groups of subjects together with "reference" tasks known to sample certain human abilities. Correlations between these criterion task scores and reference task scores specify the ability requirements (and changes in these requirements) as a function of criterion task variations. In this way, Fleishman and his colleagues found that under certain circumstances, the criticality levels or importance of certain human abilities grew while others did not. In other circumstances, the very mix of human abilities involved changed relative to a baseline condition. Thus, human abilities possess the potential to relate changes in human performance to task properties. Indeed, the POET model, as presented in this report, postulates that human abilities modulate task and environmental effects.

Criterion 11 (the last we will consider) says that the taxonomy should be applicable to all system levels. In this regard, the human abilities taxonomy is indeed applicable at all system levels, from the activity element to the sub-task to the operation to the job. Fleishman, for instance, has made use of the human abilities taxonomy for job classification (a macro-level of analysis) as well as for development of a standardized laboratory performance assessment battery (a micro-level analysis). Perhaps the most important point to remember in regard to this criterion is that the more global the

system level being described, the more imprecise the taxonomic characterization in its particulars. One can consider that, for example, a job requires explosive strength but what does this mean? It means that, over some portion of the task's period of performance, explosive strength is required. The criticality of explosive strength to this global task might be rated low because the task demands it relatively infrequently. During that sub-interval of performance time that explosive strength is required, however, one might guess correctly that its critical rating would almost certainly increase. This is a problem of level of analysis, not system of description, in our opinion. The more general the unit of analysis, the less precise the description. But what is precise enough depends on the purposes of the analysis.

4.5 Human Performance Databases: Information Search and Retrieval

Given a human abilities (or other) taxonomy with which to index a human performance database, how might search and retrieval take place? To address this question, consider the example in Figure 4.5.1. This figure profiles three tasks (T_1, T_2, and T_3) in terms of, for purposes of illustration, only five human abilities (H_a, H_b, H_c, H_d, and H_e).

One means of representing these data is to construct a vector for each task with the mean criticality ratings serving as elements, i.e., as the coordinates in the 5-dimensional human abilities space:

Task T_1: [0 2 2 0 7]

Task T_2: [6 7 5 2 0]

Task T_3: [5 6 4 1 1]

One can use this vector representation to carry out searches of the database for data which are "relevant", i.e., in some sense suitable for human performance modeling. The next question is, then, how to carry out the search. One obvious way is to search for <u>exact</u> matches to a "query" vector which characterizes a to-be-modeled task. Thus, if a task record in the human performance database did not have the exact set and criticality mix of human abilities as the to-be-modeled task, that record would be passed over. It should be obvious that with such strict criteria of relevance, the database system might retrieve few (if any data) for the user while at the same time passing over records which might be useful.

A second, related, alternative might be to relax the definition of "exact" to mean, "same mix of abilities, not necessarily same amount or criticality". To accomplish this, the human performance database might convert the task vector criticalities into 1s and 0s, i.e., any criticality rating greater than zero is given a 1, otherwise 0. This scheme would perhaps retrieve more records from the database, but at the cost of lost criticality information. Furthermore, it is still possible to miss many records which might be relevant to the user's modeling problem. For example, shall we ignore database records which are exact matches in the abilities involved in the to-be-modeled task if those records include other abilities as well?

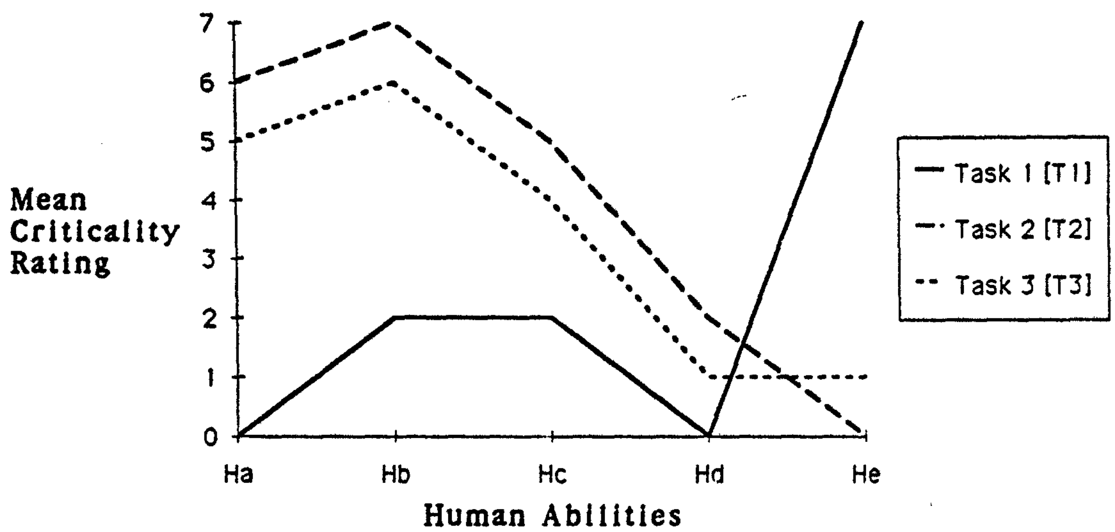


Figure 4.5.1. Task Profiles in terms of 5 Human Abilities (hypothetical data).

A more robust alternative to exact match strategies are similarity approaches. Salton and McGill (1983) present several such approaches, but only one of the most common metrics is presented here for purposes of illustration. This similarity metric, called the cosine coefficient is given, for p-dimensional vectors, as:

$$COSINE(Task_i, Task_j) = \frac{\sum_{K=1}^{P} (Term_{ik} * Term_{jk})}{\sqrt{\sum_{K=1}^{P} (Term_{ik})^2 * \sum_{K=1}^{P} (Term_{jk})^2}}$$

The cosine coefficient is a measure of the angle between two p-dimensional task vectors when the vectors are considered as ordinary vectors in, say, a human abilities space of p-dimensions. If two task vectors are identical, they will lie atop one another in this hyperspace and the angle between them is zero. At the other extreme, two task vectors with nothing in common will be orthogonal to each other in this hyperspace, which corresponds to an angle of 90 degrees, the cosine of which is 1. . Assuming that all elements of the task vectors are non-negative, the cosine coefficient takes on values from 0 (exact match) to 1 (no similarity at all). More generally, the cosine of the angle between two data vectors is the sample correlation coefficient.

Given similarity coefficients, it is no longer necessary to search for exact matches. Instead, in searching for data with which to model a particular task or set of tasks, one might set a similarity threshold, say, .5, and seek out records from the human performance database which meet or exceed this threshold. A modern information retrieval system could also return the finds and display them in decreasing order of similarity, thus aiding the modeler further.

However, while similarity coefficients provide a means to measure modeling relevance, they do not provide an answer to the question "how similar is similar enough?" The answer to this question is situation specific, we believe. Furthermore, the simple coefficients provided above are not well suited to non-compensatory searches. For example, if the modeler says he wants to search for human abilities of a specific type and amount, then no record is "relevant" if it does not meet these specifications; one cannot trade off similarity in other dimensions. In this case, the cosine coefficient must be replaced by other, more appropriate, procedures.

In order to complete this section, we can look at the cosine coefficients between T_1, and T_2, and between T_2 and T_3:

$$COSINE\ (T_1,\ T_2) = \frac{0*6 + 7*2 + 2*5 + 0*2 + 7*0}{[(0^2+2^2+2^2+0^2+7^2) * (6^2+7^2+5^2+2^2+0^2)]^{1/2}} = \frac{24}{80.6} = .2978$$

$$COSINE\ (T_2,\ T_3) = \frac{6*5 + 7*6 + 5*4 + 2*1 + 0*1}{[(6^2+7^2+5^2+2^2+0^2) * (5^2+6^2+4^2+1^2+1^2)]^{1/2}} = \frac{94}{94.89} = .9906$$

These similarity calculations indicate that Task 3 is more similar to Task 2 than it is to Task 1, a finding consistent with the profiles given in Figure 4.5.1. Note, however, that as the number of index terms grows (i.e., as the dimensionality of each data vector, p, grows), the correspondingly long data vectors will normally produce small cosine similarities (Salton and McGill, 1983). The implication of this is best appreciated with an example. Say you want to model a task (T_m) with two human abilities (H_a, H_b) out of a total set of only four (4) abilities. For any given record in the human performance database, the cosine coefficient will be much higher than if you want to model the same task (T_m) with two human abilities (H_a, H_b) but against the backdrop of a set of, say, 52 abilities. All this is just another way of illustrating an old rule of information search: "The more different comparisons you make, the more likely you are to find differences."

4.6 Summary

A better understanding of human performance in conditions of Chemical, Biological, and Radiological Defense (CBR-D) plays an important part in the ability of U.S. forces to not only survive but prevail in the event of enemy chemical attack. Recent work on technology to describe and predict soldier performance in conventional and chemical warfare scenarios has led to the development of a sequential network simulation software system called Micro SAINT. The objective of this study was the application of Micro SAINT simulation models of the Close-In Weapon System (CIWS) loading operation to describe and predict performance on a multi-man operation in both conventional and CBR-D conditions.

The first task of this study made use of Micro SAINT simulation and an operations research scheduling heuristic to identify procedural enhancements to the loading operation and assess the impact of different manning levels (2-man through 5-man loading crews) on completion times. The results can be used by the Fleet in two ways. First, the enhanced procedures described in this report can be integrated into the CIWS training curriculum and provide a standardized approach to CIWS weapon loading as part of the SEAOPS surface fleet standardization program. Second, the manning impact assessments can provide commanders with some indication of the effects of crew downsizing or augmentation on expected completion times to load or reload the CIWS.

The second task of this study was to take data from an existing Army database of tasks performed in shirtsleeve and in MOPP IV gear and feed Micro SAINT models of the CIWS weapon loading operation to estimate the effects of MOPP IV on this topside operation. A taxonomic approach based on human abilities was attempted in order to assess the comparability of tasks in the Army database to CIWS loading tasks and subtasks. Task Time Multipliers (TTMs), a ratio of MOPP IV completion time over shirtsleeve completion time, would be used to modify the Micro SAINT simulations in the laboratory without the need to collect additional data. For reasons described in this report, this modeling effort proved infeasible. However, the taxonomic approach offers great promise in facilitating human performance modeling and database development in the future. Issues in applying the taxonomic (human abilities) approach are discussed.

References

Bergquist, T., & Guthals, J. (1991). Integrating task-level data bases. Impacts Bulletin, 3(2), 1-3.

Box, G., Hunter, W.,G., & Hunter, J. S. (1978). Statistics for experimenters: An introduction to design, data analysis, and modeling. New York: John Wiley and Sons.

Chapanis, A. (1970). The relevance of laboratory studies to practical situations. Ergonomics, 10(5), 557-577.

Companion, M. A., & Corso, G. M. (1982). Task taxonomies: A general review and evaluation. International Journal of Man-Machine Studies, 17, 459-472.

Fleishman. E. A. (1978). Relating individual differences to the dimensions of human tasks. Ergonomics. 21(12), 1007-1019.

Fleishman, E. A. (1990). Manual for Ability Requirement Scales (MARS): Form A (Revised). In press.

Fleishman, E., A., & Quaintance, M. K. (1984). Taxonomies of human performance: The description of human tasks. Orlando: Academic Press.

Gavron, V., Drury, C., Czaja, S., & Wilkins, D. (1989). A taxonomy of independent variables affecting human performance. International Journal of Man-Machine Studies, 31, 643-672.

Gopher, D. and Kimchi, R. (1989). Engineering psychology. Annual Review of Psychology, 40, 431-455.

Hackman, J. R. (1969). Toward understanding the role of tasks in behavioral research. Acta Psychologica, 31, 97-128.

Levine, J. (1990). Personal communication.

Mallamad, S., Levine, J. M., & Fleishman, E. (1980). Identifying ability requirements by decision flow diagrams. Human Factors, 22(1), 57-68.

Meister, D. (1989). Conceptual aspects of human factors. Baltimore: Johns Hopkins Press.

Melton, A., & Briggs, G. (1960). Engineering psychology. Annual Review of Psychology, 11, 71-98.

Perrow, C. (1984). Normal accidents: Living with high-risk technologies. New York: Basic Books.

Pew, R. W., & Baron, S. (1983). Perspectives on human performance modeling. Automatica, 19(6), 663-676.

Pulat, B., M., & Pulat, P. S. (1985). A workstation assessor for crew operations -- WOSTAS. International Journal of Man-Machine Systems, 22, 103-126.

Salton, G., & McGill M. J. (1983). Introduction to modern information retrieval. New York: McGraw-Hill.

Tijerina, L., & Treaster, D. (1987). Close-In Weapon System (CIWS) Part 1: Micro SAINT model development (Contract No. DAAH-1-84-D-0001, D.O. 0062). Columbus, OH: Battelle Columbus Division.

Treaster, D., & Tijerina, L. (1988). Micro SAINT modeling of the Close-In Weapon System loading operation: Internal validation and sensitivity analysis (Contract No. DAAL03-86-D-0001, D.O. 0494). Columbus, OH: Battelle.

Weapons/Navy (1990, January). Seapower, p. 212

APPENDIX A

Tutorial on Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) Calculations

Appendix A

Tutorial on Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) Calculations

Introduction

The Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT), were used to develop the alternative CIWS manning models for Task 1 of this project. This appendix describes CPM and PERT concepts and calculations.
The following information is needed in order to use these methods:

- a listing of tasks or activities which comprise the operation,
- the precedence relations among these activities, and
- estimates of the completion time for each activity.

This information can be used to produce a graph called a network diagram which depicts the predecessor and successor relationships among activities and includes annotations of the completion time estimates for each activity.

In CPM, a single, deterministic, completion time estimate is used for each activity element. A series of relatively simple calculations on these time estimates are computed to can find the longest route through the network diagram -- the critical path. The length of this path indicates the minimum time needed to complete the operation, i.e. critical path time. Any delays on this critical path will cause delays in the completion of the whole operation. Delays of activities not on the critical path, on the other hand, will not necessarily hold up completion of the operation unless the delays exceed available slack times (to be defined later).

PERT is like CPM except that it handles uncertainty in the completion time estimates. Three completion time estimates are collected, usually by subjective assessments by experts: most likely (t_m), optimistic (t_o), and pessimistic (t_p). These three estimates are then combined to produce an expected completion time (t_e) based on the assumption that completion times are Beta distributed.

Developing the network diagram

A network diagram is developed from a listing of activities which comprise the operation, e.g., a task inventory. The next step, defining the precedence relations among activities, must be done carefully. In general, a precedence relation means that a successor activity cannot begin until all predecessors are finished. It is usually easiest to consider these relations by going from the start of the operation (technically known as the "source" of the network) and working outward to the end of the operation (technically known as the "sink" of the network). The network diagram possesses transitivity properties. That is, if activity A precedes B, and activity B precedes C, this implies that activity A precedes C and so it is not necessary to include A as an explicit precedent of C. If the analyst does include extraneous precedence relations, it makes the construction of the network more difficult. If

only a part of an activity may need to be completed before the successor may begin, this is handled by breaking down the former activity into two or more subactivities which satisfy the precedence relation described above.

When constructing the network diagram, activity-on-node diagrams may be used. With activity-on-node diagrams (which most closely resemble Micro SAINT diagrams), the nodes are activities and the arcs are merely precedence links. Dummy nodes are introduced to insure that the network has only one start node (source) and only one end node (sink). Dummy node activities are assumed to take zero time to complete.

The expected time, t_e, for an activity from PERT is derived by assuming the most probable time, t_m, is 4 times more likely to occur than the optimal or pessimistic times, which are equally likely to occur. These assumptions are based on the properties of the Beta distribution mentioned earlier. From this, the t_e value can be computed from the following formula:

$$t_e = \frac{t_o + 4t_m + t_p}{6} \qquad (1)$$

The standard deviation (sd), for an activity from PERT is derived by assuming that the optimal time estimate, t_o, is 3 sd units below the expected time, t_e, and the pessimal time estimate, t_p, is 3 sd units above the expected time in the unimodal Beta distribution. That is, they represent the endpoints of a 6 sd range in the activity completion time. From this, the sd value for an activity is computed from the following formula:

$$sd = \frac{t_p - t_o}{6} \qquad (2)$$

Table A.1 provides data on a simple example with which to assimilate what has been explained thus far. It consists of 7 tasks (not including dummy tasks). The CPM time (assumed fixed) and also the PERT time estimates are provided. Note that, for convenience only, the CPM time equals the expected time in the PERT estimates. Because CPM times are deterministic and PERT times are probabilistic, there really can be no formal relation between the two. One might speculate, however, on a subject matter expert's estimate of 'average completion time' really means. Figure A.1 depicts the corresponding network diagram for the example data.

Critical Path Calculations

Critical path calculations are performed in order to identify the critical path and also to provide indications of how much slack time is associated with non-critical path activities. The analysis requires a forward pass through the network to establish the earliest start and finish times (EST and EFT, respectively) possible with the precedence constraints which apply. A backward pass is then conducted to determine the latest start and finish times (LST and LFT, respectively) possible with the precedence constraints which apply. These calculations may be carried out by means of a tabular method, described below.

Table A.1.

Activity	Predecessors	CPM Time	PERT Estimates tp	tm	to	te	sd
A	Start	5	6.00	5.00	4.00	5.00	0.33
G	Start	11	17.00	11.00	5.00	11.00	2.00
B	A	5	8.00	5.00	2.00	5.00	1.00
C	A	6	10.00	5.50	2.00	6.00	1.00
D	A, G	7	12.00	7.00	2.00	7.00	1.67
E	B, C	3	5.00	3.00	1.00	3.00	0.67
F	E, D	8	15.00	7.00	5.00	8.00	1.67

Refer to Table A.2. It is built by ordering the activities such that all predecessors of an activity are listed before the activity itself is entered. Consider the forward pass. All activities without predecessors are assigned the same earliest start time (EST), normally zero (cf., activities A and G). The earliest finish time (EFT) for an activity is simply its earliest start time plus its duration. For example, the duration for activity G is 11 minutes, so its EFT is

EFT(G) = EST(G) + Duration(G) = 0 + 11 = 11.

The earliest start time of the remaining activities depends on the earliest finish times (EFTs) of all immediate predecessors. Specifically, the earliest start time (EST) for an activity is equal to the maximum earliest finish time (EFT) of its immediate predecessors. If an activity has only a single predecessor, its EST is equal to the earliest finish time (EFT) of that predecessor. For example, since activity C has only activity A as its predecessor, its earliest start time is 5, the EFT of activity A. The maximum earliest finish time from two or more immediate predecessors is used as the earliest start time for a successor activity because, in order for an activity to begin, ALL of its predecessors must be completed. That is, the earliest an activity could start is after the longest/slowest predecessor is completed. For example, activity E has an EST of 11, the longest EFT among predecessor activities B (EFT = 10) and C (EFT = 11). This procedure is continued until all the EST and EFT values have been determined. Note that the maximum EFT determines the minimum project duration or the critical path time. In other words, given the indicated task listing, precedence relations, and completion times (or estimates), one cannot expect to complete the operation with greater efficiency.

The latest times are then found by performing a backward pass starting at the bottom of the table. This backward pass is the reverse of the forward pass; the activities are examined in reverse order, and the latest finish time (LFT) is determined before the latest start time (LST).

The first entries are the LFTs of all activities ending at the terminal node or sink; in the example, this is activity F. These times are normally the critical path time (26 time units in the example). The latest start times (LST) are then found by subtracting from the LFT the activity duration for the activity. For example, the LST for activity F is:

LST(F) = LFT(F) - Duration = 26 - 8 = 18.

The latest finish time (LFT) for each of the remaining activities, in order, is equal to the minimum latest start time of all its immediate successors. If an activity only has one successor, its LFT is equal to that successor's LST; e.g., activity E has only activity F as its successor, so LFT(E) = LST(F) = 18. On the other hand, activity A has three successors: B, C, and D, with LST(B) = 10, LST(C) = 9, and LST(D) = 11; therefore, activity A's LFT is

LFT(A) = min(LST(B), LST(C), LST(D)) = min(10, 9, 11) = 9.

Table A.2.

Node	Duration	Early Times Start (EST)	Early Times Finish (EFT)	Late Times Start (LST)	Late Times Finish (LFT)	Free Slack	Slack
A	5	0	5	4	9	4	0
G	11	0	11	0	11	0	0
B	5	5	10	10	15	5	1
C	6	5	11	9	15	4	0
D	7	11	18	11	18	0	0
E	3	11	14	15	18	4	4
F	8	18	26	18	26	0	0

Critical Path Time = 26

EST = MAX (EFT of Predecessors), if any
= 0, otherwise

EFT = EST + Duration

LFT = CPM Time, if no successors
= MIN (LST of Successors), otherwise

LST = LFT - Duration

Slack(x) = LST(x) - EST(x)
Free Slack(x) = EFT(x) - MIN (EST(.) of immediate successors)

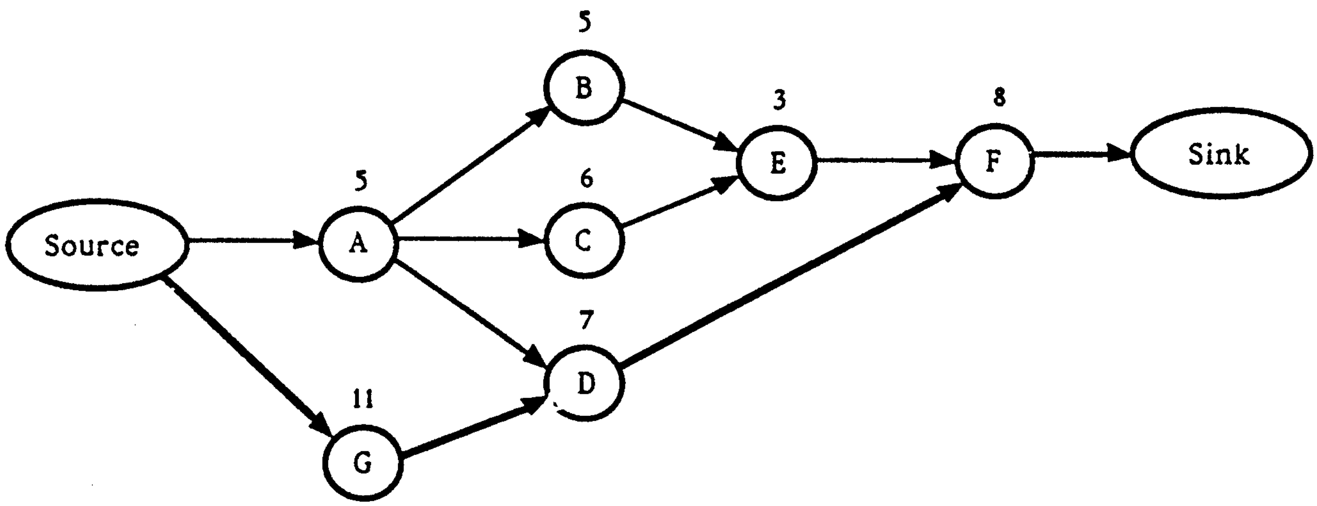


Figure A.1. Example Network.

The minimum LST from two or more immediate successors is used as the latest finish time (LFT) or a predecessor activity because, in order to insure that the operation is completed in critical path time (i.e., minimum time), each and every predecessor activity must be completed and "ready" for the successor which will begin the soonest. This translates into the minimum latest start time of that activity's successors. This procedure is continued until all the latest finish and start times are determined.

<u>Slack</u> times are found by computing the difference between the EST and the LST for each activity. A <u>critical path</u> is a connected set of activities from the source to the sink, each with zero slack. An activity on a critical path is critical because delaying its start would delay the completion time for the entire operation. Hence, it makes sense that an activity on a critical path would have zero slack. The critical path for the example is highlighted in Figure A.1.

Non-zero slack indicates the maximum amount of time by which an activity's EFT can be delayed without affecting any activity on the critical path. If the delay is greater than the slack time, then the critical path is affected and overall completion time is increased accordingly. One subtle implication of slack is that by using slack time up for one activity (e.g., by delaying the start of that activity), one oftentimes shortens the available slack time for successor activities. For example, if the start of activity A is delayed to minute 4 (using up its slack time), this reduces the slack time for successor activity B from 5 minutes to 1 minute because B must still be completed no by no later than minute 15 in order for its successor activity, E, to begin on time. Similarly, activity A's successor, C, then loses all of its slack time since it must also be completed by minute 15 so that activity E can begin without delay.

PERT statistical estimates can now be computed on the critical path. First, a standard deviation for the critical path times is determined by pooling all component activities' standard deviations by the following formula:

$$sd_{cp} = \{sd_G^2 + sd_D^2 + sd_F^2\}^{1/2} \tag{3}$$

For the example,

$$sd_{cp} = \{2.0^2 + 1.67^2 + 1.67^2\}^{1/2} = 9.58^{1/2} = 3.09.$$

By using standard statistical concepts, one may then make statements about the distribution of completion times. Even though PERT assumes that individual activity times are Beta distributed, PERT likewise assumes (justifiably or not) that the path time is normally distributed because of the central limit theorem. This assumption allows one to use standard normal tables to determine the probability of, say completing the operation by a given time via the following formula:

$$Z = \frac{t_d - t_{ecp}}{sd_{cp}} \tag{4}$$

where

t_d = desired completion time

t_{ecp} = expected completion time for the critical path

sd_{cp} = pooled estimate for critical path standard deviation

For example, the probability of completing the operation in 22 minutes or less is:

$$Z = \frac{t_d - t_{ecp}}{sd_{cp}} = \frac{22 - 26}{3.09} = -1.29.$$

Referring this Z-value to a standard normal table indicates the probability of completing the operation in 22 minutes or less to be .098.

Similarly, one can determine the completion time within which the operation can be completed, say, 95% of the time. the standard normal Z-score associated with a cumulative probability of .95 is 1.64, and this is used to solve for the t_d value of interest. From formula 3:

$$.95 = \frac{t_d - 26}{3.09} \implies t_d = (3.09)*.95 + 26 = 28.93 \text{ minutes}$$

Thus, the example operation can be completed within about 29 minutes 95% of the time.

Two final notes are provided on PERT calculations. First, PERT traditionally treats all estimates as population parameters and does not, therefore, adjust for sample size. This is because subjective assessments are usually used and there is no objective sample, per se, upon which subject matter experts base their judgements. Second, PERT statistical analyses are based solely on the critical path, not the operation as a whole. Unless the critical path is significantly longer than the other paths in the network, it may be a poor assumption that the probabilities of completing the operation and the critical path are the same (Sadowski and Medeiros, 1982). Simulation frees the analyst from the assumptions of beta distributed completion times for component activities. Simulation also exercises the whole operation, not just the critical path, and this should enhance the accuracy of the completion times and, with repeated trials, allow for the distribution of the mean to be approximated. Thus, simulation results apply to the operation, not just a critical path.

References

Sadowski, R. P., & Medeiros, D., J. (1982). Planning and control for manufacturing systems and projects. In G. Salvendy (Ed.), Handbook of Industrial Engineering (pp. 11.2.1 - 11.2.24). New York: John Wiley.

Moder, J. J., Phillips, C. R., & Davis, E. W. (1983). Project management with CPM, PERT, and precedence diagramming. New York: Van Nostrand Reinhold.

Wiest, J. D., & Levy, F. K. (1969). A management guide to PERT/CPM. Englewood Cliffs, NJ: Prentice-Hall.

APPENDIX B

Micro SAINT Models For 2-, 3-, 4-, and 5-Man Crews

TASK NETWORK

Network Number: 0
(1) Name: ciws2man (2) Type: Network
(3) Upper Network:
(4) Release Condition: 1;
(5) First sub-job: 100 start
(6) Sub-jobs (each can be task or network):

Number:	Name:	Type:
100	start	Task
1	Unlock Locker	Task
2	Undo dogs	Task
10	Remove shield pins	Task
12	Time Drum	Task
3	Open Locker	Task
11	Stow shield	Task
13	Open rnds latch	Task
14	Position loader	Task
15	Secure loader	Task
16	Align Ls & Rs	Task
17	Release tray	Task
18	Lift, fastn tray	Task
19	Hand off belt	Task
20	Start belt end	Task
21	Lower tray	Task
22	Lock tray	Task
23	Finish belt pos	Task
23a	Clip Belt 1 pc	Task
28	Activ. Hydraul	Task
4	Move Box 1	Task
5	Move Box 2	Task
6	Move Box 3	Task
7	Move Box 4	Task
8	Move Box 5	Task
9	Move loader	Task
29	Upload Box 1	Task
24	Clip Belts 1 & 2	Task
30	Upload Box 2	Task
25	Clip Belts 2 & 3	Task
31	Upload Box 3	Task
26	Clip Belts 3 & 4	Task
32	Upload Box 4	Task
27	Clip Belts 4 & 5	Task
33	Upload Box 5	Task
34	Deact. hydraul	Task
35	Loosen loader	Task
36	Lift off loader	Task
37	Secur rnds latch	Task
38	Grasp shield	Task
39	Position shield	Task
101	Finish	Task
40	Fasten shield	Task

Task Number: 100
(1) Name: start (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;
(8) Task's beginning effect:
(9) Task's ending effect: crew1=1; crew2=1;
(10) Decision Type: Multiple
Following Task/Network: Probability Of Taking
Number: Name: This Path:

```
(11)  1              Unlock  (12)  1;
(13)  10             Remove  (14)  1;
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  1
(1)  Name:  Unlock Locker                      (2)  Type:  Task
(3)  Upper Network:  0  ciws2man
(4)  Release Condition:  crew1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  16.20;
(7)  Standard deviation:  5.84;
(8)  Task's beginning effect:  crew1=0;
(9)  Task's ending effect:  unlock = 1; crew1=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:         Name:         This Path:
(11)  2              Undo d  (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  2
(1)  Name:  Undo dogs                          (2)  Type:  Task
(3)  Upper Network:  0  ciws2man
(4)  Release Condition:  crew1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  28.60;
(7)  Standard deviation:  21.37;
(8)  Task's beginning effect:  crew1=0;
(9)  Task's ending effect:  undo = 1; crew1=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:         Name:         This Path:
(11)  12             Time D  (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  10
(1)  Name:  Remove shield pins                 (2)  Type:  Task
(3)  Upper Network:  0  ciws2man
(4)  Release Condition:  crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  7.8;
(7)  Standard deviation:  3.19;
(8)  Task's beginning effect:  crew2=0;
(9)  Task's ending effect:  crew2=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:         Name:         This Path:
(11)  11             Stow s  (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
```

(21) (22)
(23) (24)

Task Number: 12
(1) Name: Time Drum (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 25.7;
(7) Standard deviation: 12.44;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: timedrum = 1;
crew1=1; crew2=1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 3	Open L	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 3
(1) Name: Open Locker (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: unlock & undo & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.6;
(7) Standard deviation: 2.29;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: crew1=1; crew2=1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 4	Move B	(12)	1;
(13) 9	Move 1	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 11
(1) Name: Stow shield (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 3.0;
(7) Standard deviation: 1.48;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 13	Open r	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 13

(1) Name: Open rnus latch (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 7.52;
(7) Standard deviation: 2.90;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: openltch = 1; crew2=1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	12	Time D	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 14
(1) Name: Position loader (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: moveload & openltch & timedrum & crewl;
(5) Time Distribution Type: Gamma
(6) Mean Time: 8.9;
(7) Standard deviation: 1.91;
(8) Task's beginning effect: crewl=0;
(9) Task's ending effect: posnload=1; crewl=1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	15	Secure	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 15
(1) Name: Secure loader (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: posnload & crewl & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 17.6;
(7) Standard deviation: 5.92;
(8) Task's beginning effect: crewl=0; crew2=0;
(9) Task's ending effect: crewl=1; crew2=1;
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	16	Align	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 16
(1) Name: Align Ls & Rs (2) Type: Task
(3) Upper Network: C ciws2man
(4) Release Condition: crewl & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 20.30;

```
(7)  Standard deviation:  0.50;
(8). Task's beginning effect:  crew1=0; crew2=0;
(9)  Task's ending effect:  aligned = 1; crew1=1; crew2=1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:        Name:         This Path:
(11)  19             Hand o   (12)  1;
(13)  17             Releas   (14)  1;
(15)                          (16)
(17)                          (18)
(19)                          (20)
(21)                          (22)
(23)                          (24)

Task Number:  17
(1)  Name:  Release tray                       (2)  Type:  Task
(3)  Upper Network:  0  ciws2man
(4)  Release Condition:  crew1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  1.7;
(7)  Standard deviation:  .49;
(8)  Task's beginning effect:  crew1=0;
(9)  Task's ending effect:  crew1=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:        Name:         This Path:
(11)  18             Lift,    (12)  1;
(13)                          (14)
(15)                          (16)
(17)                          (18)
(19)                          (20)
(21)                          (22)
(23)                          (24)

Task Number:  18
(1)  Name:  Lift, fastn tray                   (2)  Type:  Task
(3)  Upper Network:  0  ciws2man
(4)  Release Condition:  crew1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  5.5;
(7)  Standard deviation:  2.79;
(8)  Task's beginning effect:  crew1=0;
(9)  Task's ending effect:  fastntry = 1; crew1=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:        Name:         This Path:
(11)  19             Hand o   (12)  1;
(13)                          (14)
(15)                          (16)
(17)                          (18)
(19)                          (20)
(21)                          (22)
(23)                          (24)

Task Number:  19
(1)  Name:  Hand off belt                      (2)  Type:  Task
(3)  Upper Network:  0  ciws2man
(4)  Release Condition:  movbox1 & fastntry & crew1 & crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  3.4;
(7)  Standard deviation:  .93;
(8)  Task's beginning effect:  crew1=0; crew2=0;
(9)  Task's ending effect:  handoff = 1; crew1=1; crew2=1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
```

Number: Name: This Path:

(11) 20 Start (12) 1;
(13) 5 Move B (14) 1;
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 20
(1) Name: Start belt end (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: handoff & aligned & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 34.8;
(7) Standard deviation: 9.86;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 21 Lower (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 21
(1) Name: Lower tray (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.80;
(7) Standard deviation: 1.03;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 22 Lock t (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 22
(1) Name: Lock tray (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.7;
(7) Standard deviation: 4.42;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: locktray = 1; crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 23 Finish (12) 1;
(13) (14)
(15) (16)
(17) (18)

(19) (20)
(21) (22)
(23) (24)

Task Number: 23
(1) Name: Finisn belt pos (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 16.2;
(7) Standard deviation: 5.10;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: finposn = 1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 23a	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 23a
(1) Name: Clip Belt 1 pc (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: finposn & movbox1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: clip1pc = 1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 29	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 28
(1) Name: Activ. Hydraul (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: finposn & crew1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 4.5;
(7) Standard deviation: 1.71;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: activhyd = 1; crew1=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 29	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 4

(1) Name: Move Box 1 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: movbox1 = 1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 15	Secure	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 5
(1) Name: Move Box 2 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: movbox2 = 1; crew1=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 6	Move B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 6
(1) Name: Move Box 3 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: movbox3 = 1; crew1=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 7	Move B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 7
(1) Name: Move Box 4 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;

(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: movbox4 = 1; crew1=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 8	Move B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 8
(1) Name: Move Box 5 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: movbox5 = 1; crew1=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 28	Activ.	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 9
(1) Name: Move loader (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 7.1;
(7) Standard deviation: .92;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: moveload = 1; crew1=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 14	Positi	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 29
(1) Name: Upload Box 1 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: cliplpc & activhyd & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: upload1 = 1; crew1=1; crew2=1;
(10) Decision Type: Multiple
Following Task/Network: Probability Of Taking

Number: Name: This Path:
(11) 30 Upload (12) 1;
(13) 24 Clip B (14) 1;
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 24
(1) Name: Clip Belts 1 & 2 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: upload1 & movbox1 & movbox2 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: clip1\2=1; crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 30 Upload (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 30
(1) Name: Upload Box 2 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: clip1\2 & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: upload2 = 1; crew1=1; crew2=1;
(10) Decision Type: Multiple
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 31 Upload (12) 1;
(13) 25 Clip B (14) 1;
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 25
(1) Name: Clip Belts 2 & 3 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: upload2 & movbox2 & movbox3 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: clip2\3=1; crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 31 Upload (12) 1;
(13) (14)
(15) (16)
(17) (18)

(19) (20)
(21) (22)
(23) (24)

Task Number: 31
(1) Name: Upload Box 3 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: clip2\3 & crewl & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crewl=0; crew2=0;
(9) Task's ending effect: upload3 = 1; crewl=1; crew2=1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 32	Upload	(12)	1;
(13) 26	Clip B	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 26
(1) Name: Clip Belts 3 & 4 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: upload3 & movbox3 & movbox4 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: clip3\4=1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 32	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 32
(1) Name: Upload Box 4 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: clip3\4 & crewl & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crewl=0; crew2=0;
(9) Task's ending effect: upload4 = 1; crewl=1; crew2=1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 33	Upload	(12)	1;
(13) 27	Clip B	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 27

(1) Name: Clip belts 4 & 5 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: upload4 & movbox4 & movbox5 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: clip4\5=1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 33	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 33
(1) Name: Upload Box 5 (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: clip4\5 & crewl & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crewl=0; crew2=0;
(9) Task's ending effect: crewl=1; crew2=1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 34	Deact.	(12)	1;
(13) 35	Loosen	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 34
(1) Name: Deact. hydraul (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crewl;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.2;
(7) Standard deviation: .89;
(8) Task's beginning effect: crewl=0;
(9) Task's ending effect: deacthyd=1; crewl=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 38	Grasp	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 35
(1) Name: Loosen loader (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: deacthyd & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.5;

(7) Standard deviation: 2.67;
(8). Task's beginning effect: crew2=0;
(9) Task's ending effect: crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 36 Lift o (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 36
(1) Name: Lift off loader (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.34;
(7) Standard deviation: 2.19;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 37 Secur (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 37
(1) Name: Secur rnds latch (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.33;
(7) Standard deviation: 2.53;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: closltch = 1; crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 40 Fasten (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 38
(1) Name: Grasp shield (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: crew1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.71;
(7) Standard deviation: 2.39;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: graspit = 1; crew1=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking

Number: Name: This Path:
(11) 39 Positi (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 39
(1) Name: Position shield (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: closltch & graspit & crew1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.73;
(7) Standard deviation: 2.64;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: poshield = 1; crew1=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 40 Fasten (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 101
(1) Name: Finish (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Last task
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) (12)
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 40
(1) Name: Fasten shield (2) Type: Task
(3) Upper Network: 0 ciws2man
(4) Release Condition: poshield & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 8.9;
(7) Standard deviation: 4.30;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: crew1=1; crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 101 Finish (12) 1;
(13) (14)
(15) (16)
(17) (18)

(19) (20)
(21) (22)
(23) (24)

TASK NETWORK

Network Number: 0
(1) Name: ciws3man (2) Type: Network
(3) Upper Network:
(4) Release Condition: 1;
(5) First sub-job: 100 start
(6) Sub-jobs (each can be task or network):

Number:	Name:	Type:
100	start	Task
1	Unlock Locker	Task
2	Undo dogs	Task
10	Remove shield pins	Task
12	Time Drum	Task
3	Open Locker	Task
11	Stow shield	Task
13	Open rnds latch	Task
14	Position loader	Task
15	Secure loader	Task
16	Align Ls & Rs	Task
17	Release tray	Task
18	Lift, fastn tray	Task
19	Hand off belt	Task
20	Start belt end	Task
21	Lower tray	Task
22	Lock tray	Task
23	Finish belt pos	Task
23a	Clip Belt 1 pc	Task
28	Activ. Hydraul	Task
4	Move Box 1	Task
5	Move Box 2	Task
6	Move Box 3	Task
7	Move Box 4	Task
8	Move Box 5	Task
9	Move loader	Task
29	Upload Box 1	Task
24	Clip Belts 1 & 2	Task
30	Upload Box 2	Task
25	Clip Belts 2 & 3	Task
31	Upload Box 3	Task
26	Clip Belts 3 & 4	Task
32	Upload Box 4	Task
27	Clip Belts 4 & 5	Task
33	Upload Box 5	Task
34	Deact. hydraul	Task
35	Loosen loader	Task
36	Lift off loader	Task
37	Secur rnds latch	Task
38	Grasp shield	Task
39	Position shield	Task
101	Finish	Task
40	Fasten shield	Task

Task Number: 100
(1) Name: start (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;
(8) Task's beginning effect:
(9) Task's ending effect: crew1=1; crew2=1; crew3=1;

```
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  1             Unlock   (12)  1;
(13)  10            Remove   (14)  1;
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  1
(1)  Name:  Unlock Locker                          (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crew3;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  16.20;
(7)  Standard deviation:  5.84;
(8)  Task's beginning effect:  crew3=0;
(9)  Task's ending effect:  unlock = 1; crew3=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  2             Undo d   (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  2
(1)  Name:  Undo dogs                              (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crew3;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  28.60;
(7)  Standard deviation:  21.37;
(8)  Task's beginning effect:  crew3=0;
(9)  Task's ending effect:  undo = 1; crew3=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  1             Unlock   (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  10
(1)  Name:  Remove shield pins                     (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  7.8;
(7)  Standard deviation:  3.19;
(8)  Task's beginning effect:  crew2=0;
(9)  Task's ending effect:  crew2=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
```

Number: Name: This Path:
(11) 11 Stow s (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 12
(1) Name: Time Drum (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 25.7;
(7) Standard deviation: 12.44;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: timedrum = 1;
crew1=1; crew2=1;
(10) Decision Type: Multiple
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 10 Remove (12) 1;
(13) 3 Open L (14) 1;
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 3
(1) Name: Open Locker (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: unlock & undo & crew1 & crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.6;
(7) Standard deviation: 2.29;
(8) Task's beginning effect: crew1=0; crew3=0;
(9) Task's ending effect: crew1=1; crew3=1;
(10) Decision Type: Multiple
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 4 Move B (12) 1;
(13) 9 Move 1 (14) 1;
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 11
(1) Name: Stow shield (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 3.0;
(7) Standard deviation: 1.48;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:

```
(11)  13            Open r  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  13
(1)  Name:  Open rnds latch                    (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  7.52;
(7)  Standard deviation:  2.90;
(8)  Task's beginning effect:  crew2=0;
(9)  Task's ending effect:  openltch = 1; crew2=1;
(10) Decision Type:  Single choice
     Following Task/Network:       Probability Of Taking
      Number:       Name:            This Path:
(11)  14            Positi  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  14
(1)  Name:  Position loader                    (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  moveload & openltch & timedrum & crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  8.9;
(7)  Standard deviation:  1.91;
(8)  Task's beginning effect:  crew2=0;
(9)  Task's ending effect:  posnload=1; crew2=1;
(10) Decision Type:  Single choice
     Following Task/Network:       Probability Of Taking
      Number:       Name:            This Path:
(11)  15            Secure  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  15
(1)  Name:  Secure loader                      (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  posnload & crew1 & crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  17.6;
(7)  Standard deviation:  5.92;
(8)  Task's beginning effect:  crew1=0; crew2=0;
(9)  Task's ending effect:  crew1=1; crew2=1;
(10) Decision Type:  Multiple
     Following Task/Network:       Probability Of Taking
      Number:       Name:            This Path:
(11)  17            Releas  (12)  1;
(13)  16            Align   (14)  1;
```

```
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  16
(1)  Name:  Align Ls & Rs                          (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crewl & crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  20.30;
(7)  Standard deviation:  6.50;
(8)  Task's beginning effect:  crew1=0; crew2=0;
(9)  Task's ending effect:  aligned = 1; crewl=1; crew2=1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  19            Hand o   (12)  1;
(13)  28            Activ.   (14)  1;
(15)                         (15)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  17
(1)  Name:  Release tray                           (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crew3;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  1.7;
(7)  Standard deviation:  .49;
(8)  Task's beginning effect:  crew3=0;
(9)  Task's ending effect:  crew3=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  18            Lift,    (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  18
(1)  Name:  Lift, fastn tray                       (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crew3;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  5.5;
(7)  Standard deviation:  2.79;
(8)  Task's beginning effect:  crew3=0;
(9)  Task's ending effect:  fastntry = 1; crew3=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  19            Hand o   (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
```

(19) (20)
(21) (22)
(23) (24)

Task Number: 19
(1) Name: Hand off belt (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: movbox1 & fastntry & crew2 & crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 3.4;
(7) Standard deviation: .93;
(8) Task's beginning effect: crew2=0; crew3=0;
(9) Task's ending effect: handoff = 1; crew2=1; crew3=1;
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	20	Start	(12)	1;
(13)	6	Move B	(14)	1;
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 20
(1) Name: Start belt end (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: handoff & aligned & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 34.8;
(7) Standard deviation: 9.86;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: crew2=1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	21	Lower	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 21
(1) Name: Lower tray (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.80;
(7) Standard deviation: 1.03;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: crew2=1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	22	Lock t	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	

(23) (24)

Task Number: 22
(1) Name: Lock tray (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.7;
(7) Standard deviation: 4.42;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: locktray = 1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 23	Finish	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 23
(1) Name: Finish belt pos (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 16.2;
(7) Standard deviation: 5.10;
(8) Task's beginning effect: crew2=0;
(9) Task's ending effect: finposn = 1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 28	Activ.	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 23a
(1) Name: Clip Belt 1 pc (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: finposn & movbox1 & crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3=0;
(9) Task's ending effect: clip1pc = 1; crew3=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 24	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 28
(1) Name: Activ. Hydraul (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: finposn & crewl;
(5) Time Distribution Type: Gamma
(6) Mean Time: 4.5;
(7) Standard deviation: 1.71;
(8) Task's beginning effect: crewl=0;
(9) Task's ending effect: activhyd = 1; crewl=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 29	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 4
(1) Name: Move Box 1 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew3=0;
(9) Task's ending effect: movbox1 = 1; crew3=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 5	Move B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 5
(1) Name: Move Box 2 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew3=0;
(9) Task's ending effect: movbox2 = 1; crew3=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 17	Releas	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 6
(1) Name: Move Box 3 (2) Type: Task

(3) Upper Network: 0 ciws3man
(4) Release Condition: crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew3=0;
(9) Task's ending effect: movbox3 = 1; crew3=1;
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	7	Move B	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 7
(1) Name: Move Box 4 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew3=0;
(9) Task's ending effect: movbox4 = 1; crew3=1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	8	Move B	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 8
(1) Name: Move Box 5 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew3=0;
(9) Task's ending effect: movbox5 = 1; crew3=1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	23a	Clip B	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 9
(1) Name: Move loader (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: crew1;

(5) Time Distribution Type: Gamma
(6) Mean Time: 7.1;
(7) Standard deviation: .92;
(8) Task's beginning effect: crew1=0;
(9) Task's ending effect: moveload = 1; crew1=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 15	Secure	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 29
(1) Name: Upload Box 1 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: clip1pc & activhyd & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: upload1 = 1; crew1=1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 30	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 24
(1) Name: Clip Belts 1 & 2 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: upload1 & movbox1 & movbox2 & crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3=0;
(9) Task's ending effect: clip1\2=1; crew3=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 25	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 30
(1) Name: Upload Box 2 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: clip1\2 & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;

(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: upload2 = 1; crew1=1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 31	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 25
(1) Name: Clip Belts 2 & 3 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: upload2 & movbox2 & movbox3 & crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3=0;
(9) Task's ending effect: clip2\3=1; crew3=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 26	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 31
(1) Name: Upload Box 3 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: clip2\3 & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: upload3 = 1; crew1=1; crew2=1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 32	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 26
(1) Name: Clip Belts 3 & 4 (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: upload3 & movbox3 & movbox4 & crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3=0;

```
(9)  Task's ending effect:  clip3\4=1; crew3=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  27            Clip B  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  32
(1)  Name:  Upload Box 4                    (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  clip3\4 & crew1 & crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  9.9;
(7)  Standard deviation:  1.65;
(8)  Task's beginning effect:  crew1=0; crew2=0;
(9)  Task's ending effect:  upload4 = 1; crew1=1; crew2=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  33            Upload  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  27
(1)  Name:  Clip Belts 4 & 5                (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  upload4 & movbox4 & movbox5 & crew3;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  11.9;
(7)  Standard deviation:  13.09;
(8)  Task's beginning effect:  crew3=0;
(9)  Task's ending effect:  clip4\5=1; crew3=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  101           Finish  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  33
(1)  Name:  Upload Box 5                    (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  clip4\5 & crew1 & crew2;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  9.9;
(7)  Standard deviation:  1.65;
(8)  Task's beginning effect:  crew1=0; crew2=0;
(9)  Task's ending effect:  crew1=1; crew2=1;
(10) Decision Type:  Multiple
```

```
     Following Task/Network:      Probability Of Taking
      Number:         Name:         This Path:
(11)  34              Deact.   (12)  1;
(13)  35              Loosen   (14)  1;
(15)                           (16)
(17)                           (18)
(19)                           (20)
(21)                           (22)
(23)                           (24)

Task Number:  34
(1)   Name:  Deact. hydraul                      (2)  Type:  Task
(3)   Upper Network:  0  ciws3man
(4)   Release Condition:  crew1;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  2.2;
(7)   Standard deviation:  .89;
(8)   Task's beginning effect:  crew1=0;
(9)   Task's ending effect:  deacthyd=1; crew1=1;
(10)  Decision Type:  Single choice
      Following Task/Network:      Probability Of Taking
       Number:         Name:         This Path:
(11)   38              Grasp   (12)  1;
(13)                           (14)
(15)                           (16)
(17)                           (18)
(19)                           (20)
(21)                           (22)
(23)                           (24)

Task Number:  35
(1)   Name:  Loosen loader                       (2)  Type:  Task
(3)   Upper Network:  0  ciws3man
(4)   Release Condition:  deacthyd & crew2;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  11.5;
(7)   Standard deviation:  2.87;
(8)   Task's beginning effect:  crew2=0;
(9)   Task's ending effect:  crew2=1;
(10)  Decision Type:  Single choice
      Following Task/Network:      Probability Of Taking
       Number:         Name:         This Path:
(11)   36              Lift o  (12)  1;
(13)                           (14)
(15)                           (16)
(17)                           (18)
(19)                           (20)
(21)                           (22)
(23)                           (24)

Task Number:  36
(1)   Name:  Lift off loader                     (2)  Type:  Task
(3)   Upper Network:  0  ciws3man
(4)   Release Condition:  crew2;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  5.34;
(7)   Standard deviation:  2.19;
(8)   Task's beginning effect:  crew2=0;
(9)   Task's ending effect:  crew2=1;
(10)  Decision Type:  Single choice
      Following Task/Network:      Probability Of Taking
       Number:         Name:         This Path:
```

```
(11)  37           Secur  (12)  1;
(13)                      (14)
(15)                      (16)
(17)                      (18)
(19)                      (20)
(21)                      (22)
(23)                      (24)

Task Number:  37
(1)  Name:  Secur rnds latch                        (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crew2;
(5)  Time Distribution Type:  Normal
(6)  Mean Time:  6.33;
(7)  Standard deviation:  2.53;
(8)  Task's beginning effect:  crew2=0;
(9)  Task's ending effect:  closltch = 1; crew2=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  40           Fasten  (12)  1;
(13)                       (14)
(15)                       (16)
(17)                       (18)
(19)                       (20)
(21)                       (22)
(23)                       (24)

Task Number:  38
(1)  Name:  Grasp shield                            (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  crew1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  2.71;
(7)  Standard deviation:  2.39;
(8)  Task's beginning effect:  crew1=0;
(9)  Task's ending effect:  graspit = 1; crew1=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  39           Positi  (12)  1;
(13)                       (14)
(15)                       (16)
(17)                       (18)
(19)                       (20)
(21)                       (22)
(23)                       (24)

Task Number:  39
(1)  Name:  Position shield                         (2)  Type:  Task
(3)  Upper Network:  0  ciws3man
(4)  Release Condition:  closltch & graspit & crew1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  5.73;
(7)  Standard deviation:  2.64;
(8)  Task's beginning effect:  crew1=0;
(9)  Task's ending effect:  poshield = 1; crew1=1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  40           Fasten  (12)  1;
(13)                       (14)
```

(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 101
(1) Name: Finish (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Last task
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) (12)
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 40
(1) Name: Fasten shield (2) Type: Task
(3) Upper Network: 0 ciws3man
(4) Release Condition: poshield & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 8.9;
(7) Standard deviation: 4.30;
(8) Task's beginning effect: crew1=0; crew2=0;
(9) Task's ending effect: crew1=1; crew2=1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 101 Finish (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

TASK NETWORK

Network Number: 0
(1) Name: ciws3man (2) Type: Network
(3) Upper Network:
(4) Release Condition: 1;
(5) First sub-job: 100 start
(6) Sub-jobs (each can be task or network):

Number:	Name:	Type:
100	start	Task
1	Unlock Locker	Task
2	Undo dogs	Task
10	Remove shield pins	Task
12	Time Drum	Task
3	Open Locker	Task
11	Stow shield	Task

Following Task/Network: Probability Of Taking

Number:	Name:		This Path:
(11)		(12)	
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 40

(1) Name: Fasten shield (2) Type: Task

(3) Upper Network: 0 ciws3man

(4) Release Condition: poshield & crew1 & crew2;

(5) Time Distribution Type: Gamma

(6) Mean Time: 8.9;

(7) Standard deviation: 4.30;

(8) Task's beginning effect: crew1=0; crew2=0;

(9) Task's ending effect: crew1=1; crew2=1;

(10) Decision Type: Single choice

Following Task/Network: Probability Of Taking

Number:	Name:		This Path:
(11) 101	Finish	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

TASK NETWORK

Network Number: 0

(1) Name: ciws4man (2) Type: Network

(3) Upper Network:

(4) Release Condition: 1;

(5) First sub-job: 100 start

(6) Sub-jobs (each can be task or network):

Number:	Name:	Type:
100	start	Task
1	Unlock Locker	Task
2	Undo dogs	Task
10	Remove shield pins	Task
12	Time Drum	Task
3	Open Locker	Task
11	Stow shield	Task
13	Open rnds latch	Task
14	Position loader	Task
15	Secure loader	Task
16	Align Ls & Rs	Task
17	Release tray	Task
18	Lift, fastn tray	Task
19	Hand off belt	Task
20	Start belt end	Task
21	Lower tray	Task
22	Lock tray	Task
23	Finish belt pos	Task
23a	Clip Belt 1 pc	Task
28	Activ. Hydraul	Task
4	Move Box 1	Task
5	Move Box 2	Task
6	Move Box 3	Task

7	Move Box 4	Task
8	Move Box 5	Task
9	Move loader	Task
29	Upload Box 1	Task
24	Clip Belts 1 & 2	Task
30	Upload Box 2	Task
25	Clip Belts 2 & 3	Task
31	Upload Box 3	Task
26	Clip Belts 3 & 4	Task
32	Upload Box 4	Task
27	Clip Belts 4 & 5	Task
33	Upload Box 5	Task
34	Deact. hydraul	Task
35	Loosen loader	Task
36	Lift off loader	Task
37	Secur rnds latch	Task
38	Grasp shield	Task
39	Position shield	Task
101	Finish	Task
40	Fasten shield	Task

Task Number: 100
(1) Name: start (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;
(8) Task's beginning effect:
(9) Task's ending effect:
crew1 = 1; crew2 = 1; crew3 = 1; crew4 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:	Probability Of Taking This Path:
(11) 1	Unlock	(12) 1;
(13) 2	Undo d	(14) 1;
(15) 12	Time D	(16) 1;
(17)		(18)
(19)		(20)
(21)		(22)
(23)		(24)

Task Number: 1
(1) Name: Unlock Locker (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew4;
(5) Time Distribution Type: Gamma
(6) Mean Time: 16.20;
(7) Standard deviation: 5.84;
(8) Task's beginning effect: crew4 = 0;
(9) Task's ending effect: crew4 = 1; undo = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:	Probability Of Taking This Path:
(11) 3	Open L	(12) 1;
(13)		(14)
(15)		(16)
(17)		(18)
(19)		(20)
(21)		(22)
(23)		(24)

Task Number: 2
(1) Name: Undo dogs (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 28.60;
(7) Standard deviation: 21.37;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: crew3 = 1; unlock = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 3	Open L	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 10
(1) Name: Remove shield pins (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & timedrum;
(5) Time Distribution Type: Gamma
(6) Mean Time: 7.8;
(7) Standard deviation: 3.19;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: crew2 = 1; losfastn = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 11	Stow s	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 12
(1) Name: Time Drum (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 25.7;
(7) Standard deviation: 12.44;
(8) Task's beginning effect: crew1 = 0; crew2 = 0;
(9) Task's ending effect: crew1 = 1; crew2 = 1; timedrum = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 10	Remove	(12)	1;
(13) 9	Move 1	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 3
(1) Name: Open Locker (2) Type: Task

(3) Upper Network: 0 ciws4man
(4) Release Condition: crew3 & crew4 & unlock & undo;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.6;
(7) Standard deviation: 2.29;
(8) Task's beginning effect: crew3 = 0; crew4 = 0;
(9) Task's ending effect: crew3 = 1; crew4 = 1; opendoor = 1;
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	4	Move B	(12)	1;
(13)	6	Move B	(14)	1;
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 11
(1) Name: Stow shield (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & losfastn;
(5) Time Distribution Type: Gamma
(6) Mean Time: 3.0;
(7) Standard deviation: 1.48;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: stowshld = 1; crew2 = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	13	Open r	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 13
(1) Name: Open rnds latch (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & stowshld;
(5) Time Distribution Type: Gamma
(6) Mean Time: 7.52;
(7) Standard deviation: 2.90;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: crew2 = 1; openltch = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	14	Positi	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 14
(1) Name: Position loader (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & moveload & openltch & timedrum;

(5) Time Distribution Type: Gamma
(6) Mean Time: 8.9;
(7) Standard deviation: 1.91;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: posnload = 1; crew2 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 15	Secure	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 15
(1) Name: Secure loader (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & crew1 & posnload;
(5) Time Distribution Type: Gamma
(6) Mean Time: 17.6;
(7) Standard deviation: 5.92;
(8) Task's beginning effect: crew1 = 0; crew2 = 0;
(9) Task's ending effect: secrload = 1; crew1 = 1; crew2 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 17	Releas	(12)	1;
(13) 16	Align	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 16
(1) Name: Align Ls & Rs (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew1 & crew4 & secrload;
(5) Time Distribution Type: Gamma
(6) Mean Time: 20.30;
(7) Standard deviation: 6.50;
(8) Task's beginning effect: crew1 = 0; crew4 = 0;
(9) Task's ending effect: crew1 = 1; crew4 = 1; aligned = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 20	Start	(12)	1;
(13) 8	Move B	(14)	1;
(15) 28	Activ.	(16)	1;
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 17
(1) Name: Release tray (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & secrload;
(5) Time Distribution Type: Gamma
(6) Mean Time: 1.7;

(7) Standard deviation: .49;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: relstry = 1; crew2 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 18	Lift,	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 18
(1) Name: Lift, fastn tray (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & relstry;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.5;
(7) Standard deviation: 2.79;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: crew2 = 1; fastntry = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 19	Hand o	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 19
(1) Name: Hand off belt (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition:
crew2 & crew3 & movbox1 & movbox2 & fastntry;
(5) Time Distribution Type: Gamma
(6) Mean Time: 3.4;
(7) Standard deviation: .93;
(8) Task's beginning effect: crew2 = 0; crew3 = 0;
(9) Task's ending effect: crew2 = 1; crew3 = 1; handoff = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 20	Start	(12)	1;
(13) 7	Move B	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 20
(1) Name: Start belt end (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & handoff & aligned;
(5) Time Distribution Type: Gamma
(6) Mean Time: 34.8;
(7) Standard deviation: 9.86;

(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: startblt = 1; crew2 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 21	Lower	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 21
(1) Name: Lower tray (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & startblt;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.80;
(7) Standard deviation: 1.03;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: lowrtry= 1; crew2 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 22	Lock t	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 22
(1) Name: Lock tray (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & lowrtry;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.7;
(7) Standard deviation: 4.42;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: crew2 = 1; locktray = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 23	Finish	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 23
(1) Name: Finish belt pos (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & locktray;
(5) Time Distribution Type: Gamma
(6) Mean Time: 16.2;
(7) Standard deviation: 5.10;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: crew2 = 1; finposn = 1;

(10) Decision Type: Multiple
Following Task/Network: Probability Of Taking

Number:	Name:		This Path:
(11) 23a	Clip B	(12)	1;
(13) 28	Activ.	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 23a
(1) Name: Clip Belt 1 pc (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew3 & handoff & finposn & movbox1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: crew3 = 1; clip1pc = 1;
(10) Decision Type: Multiple
Following Task/Network: Probability Of Taking

Number:	Name:		This Path:
(11) 24	Clip B	(12)	1;
(13) 29	Upload	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 28
(1) Name: Activ. Hydraul (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew1 & finposn;
(5) Time Distribution Type: Gamma
(6) Mean Time: 4.5;
(7) Standard deviation: 1.71;
(8) Task's beginning effect: crew1 = 0;
(9) Task's ending effect: crew1 = 1; activhyd = 1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking

Number:	Name:		This Path:
(11) 29	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 4
(1) Name: Move Box 1 (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: opendoor & crew3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: crew3 = 1; movbox1 = 1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking

```
     Number:        Name:          This Path:
(11) 5              Move B   (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  5
(1)  Name:  Move Box 2                          (2)  Type:  Task
(3)  Upper Network:  0  ciws4man
(4)  Release Condition:  movbox1 & crew3;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  14.2;
(7)  Standard deviation:  1.30;
(8)  Task's beginning effect:  crew3 = 0;
(9)  Task's ending effect:  crew3 = 1; movbox2 = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
     Number:        Name:          This Path:
(11) 19             Hand o   (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  6
(1)  Name:  Move Box 3                          (2)  Type:  Task
(3)  Upper Network:  0  ciws4man
(4)  Release Condition:  opendoor & crew4;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  14.2;
(7)  Standard deviation:  1.30;
(8)  Task's beginning effect:  crew4 = 0;
(9)  Task's ending effect:  crew4 = 1; movbox3 = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
     Number:        Name:          This Path:
(11) 16             Align    (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  7
(1)  Name:  Move Box 4                          (2)  Type:  Task
(3)  Upper Network:  0  ciws4man
(4)  Release Condition:  1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  14.2;
(7)  Standard deviation:  1.30;
(8)  Task's beginning effect:
(9)  Task's ending effect:  movbox4 = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
     Number:        Name:          This Path:
(11) 26             Clip B   (12)  1;
```

```
(13)  27            Clip B  (14)  1;
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  8
(1)   Name:  Move Box 5                          (2)   Type:  Task
(3)   Upper Network:  0  ciws4man
(4)   Release Condition:  crew4 & aligned;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  14.2;
(7)   Standard deviation:  1.30;
(8)   Task's beginning effect:  crew4 = 0;
(9)   Task's ending effect:  crew4 = 1; movbox5 = 1;
(10)  Decision Type:  Multiple
      Following Task/Network:      Probability Of Taking
       Number:        Name:         This Path:
(11)  28            Activ.  (12)  1;
(13)  23a           Clip B  (14)  1;
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  9
(1)   Name:  Move loader                         (2)   Type:  Task
(3)   Upper Network:  0  ciws4man
(4)   Release Condition:  crewl & opendoor;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  7.1;
(7)   Standard deviation:  .92;
(8)   Task's beginning effect:  crewl = 0;
(9)   Task's ending effect:  crewl = 1; moveload = 1;
(10)  Decision Type:  Multiple
      Following Task/Network:      Probability Of Taking
       Number:        Name:         This Path:
(11)  14            Positi  (12)  1;
(13)  15            Secure  (14)  1;
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  29
(1)   Name:  Upload Box 1                        (2)   Type:  Task
(3)   Upper Network:  0  ciws4man
(4)   Release Condition:  crewl & crew2 & cliplpc & activhyd;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  9.9;
(7)   Standard deviation:  1.65;
(8)   Task's beginning effect:  crew2 = 0; crewl = 0;
(9)   Task's ending effect:  crew2 = 1; crewl = 1; uploadl = 1;
(10)  Decision Type:  Multiple
      Following Task/Network:      Probability Of Taking
       Number:        Name:         This Path:
(11)  24            Clip B  (12)  1;
(13)  30            Upload  (14)  1;
(15)                        (16)
```

(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 24
(1) Name: Clip Belts 1 & 2 (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition:
crew3 & clip1pc & upload1 & movbox1 & movbox2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: clip12 = 1; crew3 = 1;
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	25	Clip B	(12)	1;
(13)	30	Upload	(14)	1;
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 30
(1) Name: Upload Box 2 (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: upload1 & crew1 & crew2 & clip12;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew2 = 0; crew1 = 0;
(9) Task's ending effect: crew2 = 1; crew1 = 1; upload2 = 1;
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	25	Clip B	(12)	1;
(13)	31	Upload	(14)	1;
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 25
(1) Name: Clip Belts 2 & 3 (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition:
crew3 & clip12 & upload2 & movbox2 & movbox3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: clip23 = 1; crew3 = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	26	Clip B	(12)	1;
(13)			(14)	
(15)			(16)	

(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 31
(1) Name: Upload Box 3 (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: clip23 & crewl & crew2 & upload2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew2 = 0; crewl = 0;
(9) Task's ending effect: crew2 = 1; crewl = 1; upload3 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 26	Clip B	(12)	1;
(13) 32	Upload	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 26
(1) Name: Clip Belts 3 & 4 (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition:
crew3 & clip23 & upload3 & movbox3 & movbox4;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: clip34 = 1; crew3 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 27	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 32
(1) Name: Upload Box 4 (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: upload3 & crewl & crew2 & clip34;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew2 = 0; crewl = 0;
(9) Task's ending effect: crew2 = 1; crewl = 1; upload4 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 27	Clip B	(12)	1;
(13) 33	Upload	(14)	1;
(15)		(16)	
(17)		(18)	

```
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  27
(1)  Name:  Clip Belts 4 & 5                   (2)  Type:  Task
(3)  Upper Network:  0  ciws4man
(4)  Release Condition:
crew3 & clip34 & upload4 & movbox4 & movbox5;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  11.9;
(7)  Standard deviation:  13.09;
(8)  Task's beginning effect:  crew3 = 0;
(9)  Task's ending effect:  clip45 = 1; crew3 = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  33            Upload   (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  33
(1)  Name:  Upload Box 5                       (2)  Type:  Task
(3)  Upper Network:  0  ciws4man
(4)  Release Condition:  upload4 & crewl & crew2 & clip45;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  9.9;
(7)  Standard deviation:  1.65;
(8)  Task's beginning effect:  crew2 = 0; crewl = 0;
(9)  Task's ending effect:  crew2 = 1; crewl = 1; upload5 = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  34            Deact.   (12)  1;
(13)  35            Loosen   (14)  1;
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  34
(1)  Name:  Deact. hydraul                     (2)  Type:  Task
(3)  Upper Network:  0  ciws4man
(4)  Release Condition:  1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  2.2;
(7)  Standard deviation:  .89;
(8)  Task's beginning effect:  crewl = 0;
(9)  Task's ending effect:  offhydr = 1; crewl = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  35            Loosen   (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
```

(21) (22)
(23) (24)

Task Number: 35
(1) Name: Loosen loader (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & offhydr;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.5;
(7) Standard deviation: 2.87;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: loosload = 1; crew2 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 36	Lift o	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 36
(1) Name: Lift off loader (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2 & loosload;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.34;
(7) Standard deviation: 2.19;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: setaside = 1; crew2 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 37	Secur	(12)	1;
(13) 38	Grasp	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 37
(1) Name: Secur rnds latch (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crew2;
(5) Time Distribution Type: Normal
(6) Mean Time: 6.33;
(7) Standard deviation: 2.53;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: crew2 = 1; closltch = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 39	Positi	(12)	1;
(13) 40	Fasten	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 38
(1) Name: Grasp shield (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crewl & setaside;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.71;
(7) Standard deviation: 2.39;
(8) Task's beginning effect: crewl = 0;
(9) Task's ending effect: crewl = 1; graspit = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 39	Positi	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 39
(1) Name: Position shield (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: crewl & closltch & graspit;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.73;
(7) Standard deviation: 2.64;
(8) Task's beginning effect: crewl = 0;
(9) Task's ending effect: crewl = 1; posnshld = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 40	Fasten	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 101
(1) Name: Finish (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;
(8) Task's beginning effect:
(9) Task's ending effect:
crewl = 1; crew2 = 1; crew3 = 1; crew4 = 1;
(10) Decision Type: Last task

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)		(12)	
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 40

(1) Name: Fasten shield (2) Type: Task
(3) Upper Network: 0 ciws4man
(4) Release Condition: posnshld & crew1 & crew2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 8.9;
(7) Standard deviation: 4.30;
(8) Task's beginning effect: crew1 = 0; crew2 = 0;
(9) Task's ending effect: crew1 = 1; crew2 = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	101	Finish	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

TASK NETWORK

Network Number: 0
(1) Name: ciwsbase (2) Type: Network
(3) Upper Network:
(4) Release Condition: 1;
(5) First sub-job: 100 start
(6) Sub-jobs (each can be task or network):

Number:	Name:	Type:
100	start	Task
1	Unlock Locker	Task
2	Undo dogs	Task
10	Remove shield pins	Task
12	Time Drum	Task
3	Open Locker	Task
11	Stow shield	Task
13	Open rnds latch	Task
14	Position loader	Task
15	Secure loader	Task
16	Align Ls & Rs	Task
17	Release tray	Task
18	Lift, fastn tray	Task
19	Hand off belt	Task
20	Start belt end	Task
21	Lower tray	Task
22	Lock tray	Task
23	Finish belt pos	Task
23a	Clip Belt 1 pc	Task
28	Activ. Hydraul	Task
4	Move Box 1	Task
5	Move Box 2	Task
6	Move Box 3	Task
7	Move Box 4	Task
8	Move Box 5	Task
9	Move loader	Task
29	Upload Box 1	Task
24	Clip Belts 1 & 2	Task
30	Upload Box 2	Task
25	Clip Belts 2 & 3	Task
31	Upload Box 3	Task
26	Clip Belts 3 & 4	Task
32	Upload Box 4	Task
27	Clip Belts 4 & 5	Task

33	Upload Box 5	Task
34	Deact. hydraul	Task
35	Loosen loader	Task
36	Lift off loader	Task
37	Secur rnds latch	Task
38	Grasp shield	Task
39	Position shield	Task
101	Finish	Task
40	Fasten shield	Task

Task Number: 100
(1) Name: start (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	1	Unlock	(12)	1;
(13)	2	Undo d	(14)	1;
(15)	10	Remove	(16)	1;
(17)	12	Time D	(18)	1;
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 1
(1) Name: Unlock Locker (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 16.20;
(7) Standard deviation: 5.84;
(8) Task's beginning effect:
(9) Task's ending effect: undo = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	3	Open L	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 2
(1) Name: Undo dogs (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 28.60;
(7) Standard deviation: 21.37;
(8) Task's beginning effect:
(9) Task's ending effect: unlock = 1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:

```
(11)  3              Open L  (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  10
(1)   Name:  Remove shield pins                       (2)  Type:  Task
(3)   Upper Network:  0  ciwsbase
(4)   Release Condition:  1;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  7.8;
(7)   Standard deviation:  3.19;
(8)   Task's beginning effect:
(9)   Task's ending effect:
(10)  Decision Type:  Single choice
      Following Task/Network:       Probability Of Taking
       Number:        Name:          This Path:
(11)   11             Stow s  (12)  1;
(13)                          (14)
(15)                          (16)
(17)                          (18)
(19)                          (20)
(21)                          (22)
(23)                          (24)

Task Number:  12
(1)   Name:  Time Drum                                (2)  Type:  Task
(3)   Upper Network:  0  ciwsbase
(4)   Release Condition:  1;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  25.7;
(7)   Standard deviation:  12.44;
(8)   Task's beginning effect:
(9)   Task's ending effect:  timedrum = 1;
(10)  Decision Type:  Single choice
      Following Task/Network:       Probability Of Taking
       Number:        Name:          This Path:
(11)   14             Positi  (12)  1;
(13)                          (14)
(15)                          (16)
(17)                          (18)
(19)                          (20)
(21)                          (22)
(23)                          (24)

Task Number:  3
(1)   Name:  Open Locker                              (2)  Type:  Task
(3)   Upper Network:  0  ciwsbase
(4)   Release Condition:  unlock & undo;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  6.6;
(7)   Standard deviation:  2.29;
(8)   Task's beginning effect:
(9)   Task's ending effect:
(10)  Decision Type:  Multiple
      Following Task/Network:       Probability Of Taking
       Number:        Name:          This Path:
(11)   8              Move B  (12)  1;
(13)   7              Move B  (14)  1;
```

```
(15)  6            Move B  (16)  1;
(17)  5            Move B  (18)  1;
(19)  4            Move B  (20)  1;
(21)  9            Move 1  (22)  1;
(23)                       (24)

Task Number:  11
(1)  Name:  Stow shield                          (2)  Type:  Task
(3)  Upper Network:  0  ciwsbase
(4)  Release Condition:  1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  3.0;
(7)  Standard deviation:  1.48;
(8)  Task's beginning effect:
(9)  Task's ending effect:
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:      Name:           This Path:
(11)  13           Open r  (12)  1;
(13)                       (14)
(15)                       (16)
(17)                       (18)
(19)                       (20)
(21)                       (22)
(23)                       (24)

Task Number:  13
(1)  Name:  Open rnds latch                      (2)  Type:  Task
(3)  Upper Network:  0  ciwsbase
(4)  Release Condition:  1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  7.52;
(7)  Standard deviation:  2.90;
(8)  Task's beginning effect:
(9)  Task's ending effect:  openltch = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:      Name:           This Path:
(11)  14           Positi  (12)  1;
(13)                       (14)
(15)                       (16)
(17)                       (18)
(19)                       (20)
(21)                       (22)
(23)                       (24)

Task Number:  14
(1)  Name:  Position loader                      (2)  Type:  Task
(3)  Upper Network:  0  ciwsbase
(4)  Release Condition:  moveload & openltch & timedrum;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  8.9;
(7)  Standard deviation:  1.91;
(8)  Task's beginning effect:
(9)  Task's ending effect:
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:      Name:           This Path:
(11)  15           Secure  (12)  1;
(13)                       (14)
(15)                       (16)
(17)                       (18)
```

(19) (20)
(21) (22)
(23) (24)

Task Number: 15
(1) Name: Secure loader (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 17.6;
(7) Standard deviation: 5.92;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	17	Releas	(12)	1;
(13)	16	Align	(14)	1;
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 16
(1) Name: Align Ls & Rs (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 20.30;
(7) Standard deviation: 6.50;
(8) Task's beginning effect:
(9) Task's ending effect: aligned = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	20	Start	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 17
(1) Name: Release tray (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 1.7;
(7) Standard deviation: .49;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	18	Lift,	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	

(23) (24)

Task Number: 18
(1) Name: Lift, fastn tray (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.5;
(7) Standard deviation: 2.79;
(8) Task's beginning effect:
(9) Task's ending effect: fastntry = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 19	Hand o	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 19
(1) Name: Hand off belt (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: movbox1 & fastntry;
(5) Time Distribution Type: Gamma
(6) Mean Time: 3.4;
(7) Standard deviation: .93;
(8) Task's beginning effect:
(9) Task's ending effect: handoff = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 20	Start	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 20
(1) Name: Start belt end (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: handoff & aligned;
(5) Time Distribution Type: Gamma
(6) Mean Time: 34.8;
(7) Standard deviation: 9.86;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 21	Lower	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 21
(1) Name: Lower tray (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.80;
(7) Standard deviation: 1.03;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 22	Lock t	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 22
(1) Name: Lock tray (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.7;
(7) Standard deviation: 4.42;
(8) Task's beginning effect:
(9) Task's ending effect: locktray = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 23	Finish	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 23
(1) Name: Finish belt pos (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 16.2;
(7) Standard deviation: 5.10;
(8) Task's beginning effect:
(9) Task's ending effect: finposn = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 23a	Clip B	(12)	1;
(13) 28	Activ.	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 23a
(1) Name: Clip Belt 1 pc (2) Type: Task

(3) Upper Network: 0 ciwsbase
(4) Release Condition: finposn & movbox1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect:
(9) Task's ending effect: clip1pc = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	29	Upload	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 28
(1) Name: Activ. Hydraul (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 4.5;
(7) Standard deviation: 1.71;
(8) Task's beginning effect:
(9) Task's ending effect: activhyd = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	29	Upload	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 4
(1) Name: Move Box 1 (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect:
(9) Task's ending effect: movbox1 = 1;
(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	19	Hand o	(12)	1;
(13)	23a	Clip B	(14)	1;
(15)	24	Clip B	(16)	1;
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 5
(1) Name: Move Box 2 (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;

(5) Time Distribution Type: Gamma

(6) Mean Time: 14.2;

(7) Standard deviation: 1.30;

(8) Task's beginning effect:

(9) Task's ending effect: movbox2 = 1;

(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	24	Clip B	(12)	1;
(13)	25	Clip B	(14)	1;
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 6

(1) Name: Move Box 3 (2) Type: Task

(3) Upper Network: 0 ciwsbase

(4) Release Condition: 1;

(5) Time Distribution Type: Gamma

(6) Mean Time: 14.2;

(7) Standard deviation: 1.30;

(8) Task's beginning effect:

(9) Task's ending effect: movbox3 = 1;

(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	25	Clip B	(12)	1;
(13)	26	Clip B	(14)	1;
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 7

(1) Name: Move Box 4 (2) Type: Task

(3) Upper Network: 0 ciwsbase

(4) Release Condition: 1;

(5) Time Distribution Type: Gamma

(6) Mean Time: 14.2;

(7) Standard deviation: 1.30;

(8) Task's beginning effect:

(9) Task's ending effect: movbox4 = 1;

(10) Decision Type: Multiple

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	26	Clip B	(12)	1;
(13)	27	Clip B	(14)	1;
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 8

(1) Name: Move Box 5 (2) Type: Task

(3) Upper Network: 0 ciwsbase

(4) Release Condition: 1;

(5) Time Distribution Type: Gamma

(6) Mean Time: 14.2;

(7) Standard deviation: 1.30;
(8) Task's beginning effect:
(9) Task's ending effect: movbox5 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 27	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 9
(1) Name: Move loader (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 7.1;
(7) Standard deviation: .92;
(8) Task's beginning effect:
(9) Task's ending effect: moveload = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 14	Positi	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 29
(1) Name: Upload Box 1 (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: clip1pc & activhyd;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect:
(9) Task's ending effect: upload1 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 24	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 24
(1) Name: Clip Belts 1 & 2 (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: upload1 & movbox1 & movbox2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect:

(9) Task's ending effect:
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 30	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 30
(1) Name: Upload Box 2 (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect:
(9) Task's ending effect: upload2 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 25	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 25
(1) Name: Clip Belts 2 & 3 (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: upload2 & movbox2 & movbox3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 31	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 31
(1) Name: Upload Box 3 (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect:
(9) Task's ending effect: upload3 = 1;
(10) Decision Type: Single choice

```
      Following Task/Network:      Probability Of Taking
       Number:       Name:          This Path:
(11)   26            Clip B   (12)  1;
(13)                          (14)
(15)                          (16)
(17)                          (18)
(19)                          (20)
(21)                          (22)
(23)                          (24)

Task Number:  26
(1)   Name:  Clip Belts 3 & 4                  (2)  Type:  Task
(3)   Upper Network:  0  ciwsbase
(4)   Release Condition:  upload3 & movbox3 & movbox4;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  11.9;
(7)   Standard deviation:  13.09;
(8)   Task's beginning effect:
(9)   Task's ending effect:
(10)  Decision Type:  Single choice
      Following Task/Network:      Probability Of Taking
       Number:       Name:          This Path:
(11)   32            Upload   (12)  1;
(13)                          (14)
(15)                          (16)
(17)                          (18)
(19)                          (20)
(21)                          (22)
(23)                          (24)

Task Number:  32
(1)   Name:  Upload Box 4                      (2)  Type:  Task
(3)   Upper Network:  0  ciwsbase
(4)   Release Condition:  1;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  9.9;
(7)   Standard deviation:  1.65;
(8)   Task's beginning effect:
(9)   Task's ending effect:  upload4 = 1;
(10)  Decision Type:  Single choice
      Following Task/Network:      Probability Of Taking
       Number:       Name:          This Path:
(11)   27            Clip B   (12)  1;
(13)                          (14)
(15)                          (16)
(17)                          (18)
(19)                          (20)
(21)                          (22)
(23)                          (24)

Task Number:  27
(1)   Name:  Clip Belts 4 & 5                  (2)  Type:  Task
(3)   Upper Network:  0  ciwsbase
(4)   Release Condition:  upload4 & movbox4 & movbox5;
(5)   Time Distribution Type:  Gamma
(6)   Mean Time:  11.9;
(7)   Standard deviation:  13.09;
(8)   Task's beginning effect:
(9)   Task's ending effect:
(10)  Decision Type:  Single choice
      Following Task/Network:      Probability Of Taking
       Number:       Name:          This Path:
```

(11) 33 Upload (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 33
(1) Name: Upload Box 5 (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 34 Deact. (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 34
(1) Name: Deact. hydraul (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.2;
(7) Standard deviation: .89;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 35 Loosen (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 35
(1) Name: Loosen loader (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.5;
(7) Standard deviation: 2.87;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 36 Lift o (12) 1;
(13) (14)

(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 36
(1) Name: Lift off loader (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.34;
(7) Standard deviation: 2.19;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 37	Secur	(12)	1;
(13) 38	Grasp	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 37
(1) Name: Secur rnds latch (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 6.33;
(7) Standard deviation: 2.53;
(8) Task's beginning effect:
(9) Task's ending effect: closltch = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 39	Positi	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 38
(1) Name: Grasp shield (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.71;
(7) Standard deviation: 2.39;
(8) Task's beginning effect:
(9) Task's ending effect: graspit = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 39	Positi	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	

(19) (20)
(21) (22)
(23) (24)

Task Number: 39
(1) Name: Position shield (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: closltch & graspit;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.73;
(7) Standard deviation: 2.64;
(8) Task's beginning effect:
(9) Task's ending effect: poshield = 1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 40 Fasten (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 101
(1) Name: Finish (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Last task
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) (12)
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 40
(1) Name: Fasten shield (2) Type: Task
(3) Upper Network: 0 ciwsbase
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 8.9;
(7) Standard deviation: 4.30;
(8) Task's beginning effect:
(9) Task's ending effect:
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 101 Finish (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)

TASK NETWORK

Network Number: 0
(1) Name: ciws5man (2) Type: Network
(3) Upper Network:
(4) Release Condition: 1;
(5) First sub-job: 100 start
(6) Sub-jobs (each can be task or network):

Number:	Name:	Type:
100	start	Task
1	Unlock Locker	Task
2	Undo dogs	Task
10	Remove shield pins	Task
12	Time Drum	Task
3	Open Locker	Task
11	Stow shield	Task
13	Open rnds latch	Task
14	Position loader	Task
15	Secure loader	Task
16	Align Ls & Rs	Task
17	Release tray	Task
18	Lift, fastn tray	Task
19	Hand off belt	Task
20	Start belt end	Task
21	Lower tray	Task
22	Lock tray	Task
23	Finish belt pos	Task
23a	Clip Belt 1 pc	Task
28	Activ. Hydraul	Task
4	Move Box 1	Task
5	Move Box 2	Task
6	Move Box 3	Task
7	Move Box 4	Task
8	Move Box 5	Task
9	Move loader	Task
29	Upload Box 1	Task
24	Clip Belts 1 & 2	Task
30	Upload Box 2	Task
25	Clip Belts 2 & 3	Task
31	Upload Box 3	Task
26	Clip Belts 3 & 4	Task
32	Upload Box 4	Task
27	Clip Belts 4 & 5	Task
33	Upload Box 5	Task
34	Deact. hydraul	Task
35	Loosen loader	Task
36	Lift off loader	Task
37	Secur rnds latch	Task
38	Grasp shield	Task
39	Position shield	Task
101	Finish	Task
40	Fasten shield	Task

Task Number: 100
(1) Name: start (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: 1;
(5) Time Distribution Type: Normal
(6) Mean Time: 0;
(7) Standard deviation: 0;

```
(8)  Task's beginning effect:
(9)  Task's ending effect:
crew1 = 1; crew2 = 1; crew3 = 1; crew4 = 1; crew5 = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  1             Unlock  (12)  1;
(13)  2             Undo d  (14)  1;
(15)  12            Time D  (16)  1;
(17)  10            Remove  (18)  1;
(19)                        (20)
(21)                        (22)
(23)                        (24)
```

```
Task Number:  1
(1)  Name:  Unlock Locker                          (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew5;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  16.20;
(7)  Standard deviation:  5.84;
(8)  Task's beginning effect:  crew5 = 0;
(9)  Task's ending effect:  crew5 = 1; undo = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  3             Open L  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)
```

```
Task Number:  2
(1)  Name:  Undo dogs                              (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew4;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  28.60;
(7)  Standard deviation:  21.37;
(8)  Task's beginning effect:  crew4 = 0;
(9)  Task's ending effect:  crew4 = 1; unlock = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  3             Open L  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)
```

```
Task Number:  10
(1)  Name:  Remove shield pins                     (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  7.8;
(7)  Standard deviation:  3.19;
(8)  Task's beginning effect:  crew3 = 0;
```

```
(9)  Task's ending effect:  crew3 = 1; losfastn = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  11            Stow s   (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  12
(1)  Name:  Time Drum                          (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew1 & crew3;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  25.7;
(7)  Standard deviation:  12.44;
(8)  Task's beginning effect:  crew1 = 0; crew3 = 0;
(9)  Task's ending effect:  crew1 = 1; crew3 = 1; timedrum = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  9             Move 1   (12)  1;
(13)  14            Positi   (14)  1;
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  3
(1)  Name:  Open Locker                        (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew5 & crew4 & unlock & undo;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  6.6;
(7)  Standard deviation:  2.29;
(8)  Task's beginning effect:  crew5 = 0; crew4 = 0;
(9)  Task's ending effect:  crew5 = 1; crew4 = 1; opendoor = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  4             Move B   (12)  1;
(13)  6             Move B   (14)  1;
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  11
(1)  Name:  Stow shield                        (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew3 & losfastn;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  3.0;
(7)  Standard deviation:  1.48;
(8)  Task's beginning effect:  crew3 = 0;
(9)  Task's ending effect:  stowshld = 1; crew3 = 1;
(10) Decision Type:  Single choice
```

Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 13 Open r (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 13
(1) Name: Open rnds latch (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew3 & stowshld;
(5) Time Distribution Type: Gamma
(6) Mean Time: 7.52;
(7) Standard deviation: 2.90;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: crew3 = 1; openltch = 1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 16 Align (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 14
(1) Name: Position loader (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew2 & moveload & openltch & timedrum;
(5) Time Distribution Type: Gamma
(6) Mean Time: 8.9;
(7) Standard deviation: 1.91;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: posnload = 1; crew2 = 1;
(10) Decision Type: Single choice
Following Task/Network: Probability Of Taking
Number: Name: This Path:
(11) 15 Secure (12) 1;
(13) (14)
(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 15
(1) Name: Secure loader (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew2 & crew1 & posnload;
(5) Time Distribution Type: Gamma
(6) Mean Time: 17.6;
(7) Standard deviation: 5.92;
(8) Task's beginning effect: crew1 = 0; crew2 = 0;
(9) Task's ending effect: secrload = 1; crew1 = 1; crew2 = 1;
(10) Decision Type: Multiple
Following Task/Network: Probability Of Taking
Number: Name: This Path:

```
(11)  17            Releas   (12)  1;
(13)  16            Align    (14)  1;
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  16
(1)  Name:  Align Ls & Rs                       (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew1 & crew3 & secrload;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  20.30;
(7)  Standard deviation:  6.50;
(8)  Task's beginning effect:  crew1 = 0; crew3 = 0;
(9)  Task's ending effect:  crew1 = 1; crew3 = 1; aligned = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  23a           Clip B   (12)  1;
(13)  20            Start    (14)  1;
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  17
(1)  Name:  Release tray                        (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew2 & secrload;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  1.7;
(7)  Standard deviation:  .49;
(8)  Task's beginning effect:  crew2 = 0;
(9)  Task's ending effect:  relstry = 1; crew2 = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  18            Lift,    (12)  1;
(13)                         (14)
(15)                         (16)
(17)                         (18)
(19)                         (20)
(21)                         (22)
(23)                         (24)

Task Number:  18
(1)  Name:  Lift, fastn tray                    (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew2 & relstry;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  5.5;
(7)  Standard deviation:  2.79;
(8)  Task's beginning effect:  crew2 = 0;
(9)  Task's ending effect:  crew2 = 1; fastntry = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  19            Hand o   (12)  1;
(13)                         (14)
```

(15) (16)
(17) (18)
(19) (20)
(21) (22)
(23) (24)

Task Number: 19
(1) Name: Hand off belt (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition:
crew2 & crew4 & movbox1 & movbox2 & fastntry;
(5) Time Distribution Type: Gamma
(6) Mean Time: 3.4;
(7) Standard deviation: .93;
(8) Task's beginning effect: crew2 = 0; crew4 = 0;
(9) Task's ending effect: crew2 = 1; crew4 = 1; handoff = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	20	Start	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 20
(1) Name: Start belt end (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew2 & handoff & aligned;
(5) Time Distribution Type: Gamma
(6) Mean Time: 34.8;
(7) Standard deviation: 9.86;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: startblt = 1; crew2 = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	21	Lower	(12)	1;
(13)			(14)	
(15)			(16)	
(17)			(18)	
(19)			(20)	
(21)			(22)	
(23)			(24)	

Task Number: 21
(1) Name: Lower tray (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew2 & startblt;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.80;
(7) Standard deviation: 1.03;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: lowrtry= 1; crew2 = 1;
(10) Decision Type: Single choice

	Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11)	22	Lock t	(12)	1;
(13)			(14)	
(15)			(16)	

```
(17)                            (18)
(19)                            (20)
(21)                            (22)
(23)                            (24)

Task Number:  22
(1)  Name:  Lock tray                              (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew2 & lowrtry;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  6.7;
(7)  Standard deviation:  4.42;
(8)  Task's beginning effect:  crew2 = 0;
(9)  Task's ending effect:  crew2 = 1; locktray = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  23            Finish  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  23
(1)  Name:  Finish belt pos                        (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew2 & locktray;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  16.2;
(7)  Standard deviation:  5.10;
(8)  Task's beginning effect:  crew2 = 0;
(9)  Task's ending effect:  crew2 = 1; finposn = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  23a           Clip B  (12)  1;
(13)  28            Activ.  (14)  1;
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  23a
(1)  Name:  Clip Belt 1 pc                         (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew3 & handoff & finposn & movbox1;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  11.9;
(7)  Standard deviation:  13.09;
(8)  Task's beginning effect:  crew3 = 0;
(9)  Task's ending effect:  crew3 = 1; clip1pc = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:          This Path:
(11)  24            Clip B  (12)  1;
(13)  29            Upload  (14)  1;
(15)                        (16)
(17)                        (18)
(19)                        (20)
```

(21) (22)
(23) (24)

Task Number: 28
(1) Name: Activ. Hydraul (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew1 & finposn;
(5) Time Distribution Type: Gamma
(6) Mean Time: 4.5;
(7) Standard deviation: 1.71;
(8) Task's beginning effect: crew1 = 0;
(9) Task's ending effect: crew1 = 1; activhyd = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 29	Upload	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 4
(1) Name: Move Box 1 (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: opendoor & crew4;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew4 = 0;
(9) Task's ending effect: crew4 = 1; movbox1 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 5	Move B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 5
(1) Name: Move Box 2 (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: movbox1 & crew4;
(5) Time Distribution Type: Gamma
(6) Mean Time: 14.2;
(7) Standard deviation: 1.30;
(8) Task's beginning effect: crew4 = 0;
(9) Task's ending effect: crew4 = 1; movbox2 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 19	Hand o	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

```
Task Number:  6
(1)  Name:  Move Box 3                           (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  opendoor & crew5;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  14.2;
(7)  Standard deviation:  1.30;
(8)  Task's beginning effect:  crew5 = 0;
(9)  Task's ending effect:  crew5 = 1; movbox3 = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:           This Path:
(11)  7             Move B  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  7
(1)  Name:  Move Box 4                           (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew5 & movbox3;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  14.2;
(7)  Standard deviation:  1.30;
(8)  Task's beginning effect:  crew5 = 0;
(9)  Task's ending effect:  crew5 = 1; movbox4 = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:           This Path:
(11)  8             Move B  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  8
(1)  Name:  Move Box 5                           (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  crew5 & movbox4;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  14.2;
(7)  Standard deviation:  1.30;
(8)  Task's beginning effect:  crew5 = 0;
(9)  Task's ending effect:  crew5 = 1; movbox5 = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:           This Path:
(11)  19            Hand o  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  9
(1)  Name:  Move loader                          (2)  Type:  Task
```

(3) Upper Network: 0 ciws5man
(4) Release Condition: timedrum & crew1 & opendoor;
(5) Time Distribution Type: Gamma
(6) Mean Time: 7.1;
(7) Standard deviation: .92;
(8) Task's beginning effect: crew1 = 0;
(9) Task's ending effect: crew1 = 1; moveload = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 14	Positi	(12)	1;
(13) 15	Secure	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 29
(1) Name: Upload Box 1 (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew1 & crew2 & clip1pc & activhyd;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew2 = 0; crew1 = 0;
(9) Task's ending effect: crew2 = 1; crew1 = 1; upload1 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 24	Clip B	(12)	1;
(13) 30	Upload	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 24
(1) Name: Clip Belts 1 & 2 (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition:
crew3 & clip1pc & upload1 & movbox1 & movbox2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: clip12 = 1; crew3 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 25	Clip B	(12)	1;
(13) 30	Upload	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 30
(1) Name: Upload Box 2 (2) Type: Task
(3) Upper Network: 0 ciws5man

(4) Release Condition: upload1 & crew1 & crew2 & clip12;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew2 = 0; crew1 = 0;
(9) Task's ending effect: crew2 = 1; crew1 = 1; upload2 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 25	Clip B	(12)	1;
(13) 31	Upload	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 25
(1) Name: Clip Belts 2 & 3 (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition:
crew3 & clip12 & upload2 & movbox2 & movbox3;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.9;
(7) Standard deviation: 13.09;
(8) Task's beginning effect: crew3 = 0;
(9) Task's ending effect: clip23 = 1; crew3 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 26	Clip B	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 31
(1) Name: Upload Box 3 (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: clip23 & crew1 & crew2 & upload2;
(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew2 = 0; crew1 = 0;
(9) Task's ending effect: crew2 = 1; crew1 = 1; upload3 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 26	Clip B	(12)	1;
(13) 32	Upload	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 26
(1) Name: Clip Belts 3 & 4 (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition:

```
crew3 & clip23 & upload3 & movbox3 & movbox4;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  11.9;
(7)  Standard deviation:  13.09;
(8)  Task's beginning effect:  crew3 = 0;
(9)  Task's ending effect:  clip34 = 1; crew3 = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:           This Path:
(11)  27            Clip B  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  32
(1)  Name:  Upload Box 4                        (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  upload3 & crewl & crew2 & clip34;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  9.9;
(7)  Standard deviation:  1.65;
(8)  Task's beginning effect:  crew2 = 0; crewl = 0;
(9)  Task's ending effect:  crew2 = 1; crewl = 1; upload4 = 1;
(10) Decision Type:  Multiple
     Following Task/Network:      Probability Of Taking
      Number:       Name:           This Path:
(11)  27            Clip B  (12)  1;
(13)  33            Upload  (14)  1;
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  27
(1)  Name:  Clip Belts 4 & 5                    (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:
crew3 & clip34 & upload4 & movbox4 & movbox5;
(5)  Time Distribution Type:  Gamma
(6)  Mean Time:  11.9;
(7)  Standard deviation:  13.09;
(8)  Task's beginning effect:  crew3 = 0;
(9)  Task's ending effect:  clip45 = 1; crew3 = 1;
(10) Decision Type:  Single choice
     Following Task/Network:      Probability Of Taking
      Number:       Name:           This Path:
(11)  33            Upload  (12)  1;
(13)                        (14)
(15)                        (16)
(17)                        (18)
(19)                        (20)
(21)                        (22)
(23)                        (24)

Task Number:  33
(1)  Name:  Upload Box 5                        (2)  Type:  Task
(3)  Upper Network:  0  ciws5man
(4)  Release Condition:  upload4 & crewl & crew2 & clip45;
```

(5) Time Distribution Type: Gamma
(6) Mean Time: 9.9;
(7) Standard deviation: 1.65;
(8) Task's beginning effect: crew2 = 0; crew1 = 0;
(9) Task's ending effect: crew2 = 1; crew1 = 1; upload5 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 34	Deact.	(12)	1;
(13) 35	Loosen	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 34
(1) Name: Deact. hydraul (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: 1;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.2;
(7) Standard deviation: .89;
(8) Task's beginning effect: crew1 = 0;
(9) Task's ending effect: offhydr = 1; crew1 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 35	Loosen	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 35
(1) Name: Loosen loader (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew2 & offhydr;
(5) Time Distribution Type: Gamma
(6) Mean Time: 11.5;
(7) Standard deviation: 2.87;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: loosload = 1; crew2 = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 36	Lift o	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 36
(1) Name: Lift off loader (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew2 & loosload;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.34;

(7) Standard deviation: 2.19;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: setaside = 1; crew2 = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 37	Secur	(12)	1;
(13) 38	Grasp	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 37
(1) Name: Secur rnds latch (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crew2;
(5) Time Distribution Type: Normal
(6) Mean Time: 6.33;
(7) Standard deviation: 2.53;
(8) Task's beginning effect: crew2 = 0;
(9) Task's ending effect: crew2 = 1; closltch = 1;
(10) Decision Type: Multiple

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 39	Positi	(12)	1;
(13) 40	Fasten	(14)	1;
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 38
(1) Name: Grasp shield (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crewl & setaside;
(5) Time Distribution Type: Gamma
(6) Mean Time: 2.71;
(7) Standard deviation: 2.39;
(8) Task's beginning effect: crewl = 0;
(9) Task's ending effect: crewl = 1; graspit = 1;
(10) Decision Type: Single choice

Following Task/Network: Number:	Name:		Probability Of Taking This Path:
(11) 39	Positi	(12)	1;
(13)		(14)	
(15)		(16)	
(17)		(18)	
(19)		(20)	
(21)		(22)	
(23)		(24)	

Task Number: 39
(1) Name: Position shield (2) Type: Task
(3) Upper Network: 0 ciws5man
(4) Release Condition: crewl & closltch & graspit;
(5) Time Distribution Type: Gamma
(6) Mean Time: 5.73;
(7) Standard deviation: 2.64;
(8) Task's beginning effect: crewl = 0;